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ART. XXVIII.—*Lecture on the Gulf Stream, Prepared at the Request of the American Association for the Advancement of Science;* by A. D. BACHE, Supt. U. S. Coast Survey.*

[Delivered before the American Association for the Advancement of Science, at Newport.]

BY request of the Association, at their last meeting, at Springfield, I now present a summary of the results of the Gulf Stream explorations made by the officers of the Coast Survey.

The Gulf Stream is the great hydrographic feature of the United States coast, and no survey of the coast could be complete for purposes of navigation, without it. Hence the explorations have been early undertaken and thoroughly carried on. But as it required peculiar means and special adaptation in the officers to this line of research, and did not require a continuous survey, the work has been executed from time to time, as means and officers could be had without interference with the more regular operations of the hydrography.

An act of Congress which refers to this Survey, requires the immediate presentation of its results to Congress and they have therefore been discussed as soon as procured and have been given to the public.

This is the great sea mark of the coast of the United States, both Gulf and Atlantic, and its qualities as hindrances and aids to navigation require that the navigator should be well informed in regard to it.

* Communicated by the Author.

In order to present an intelligible summary of the results obtained by the Coast Survey in the short time allowed for a lecture, it is necessary to condense the subject very considerably, to omit matters at all extraneous to the subjects in hand, and to confine myself to a brief and direct statement of *the means employed in examining the stream from its surface to its depths, the method of studying the results*, and *of the results themselves.*

The temperatures in and near the Gulf Stream, are among its most striking peculiarities, and therefore have formed one principal object of observation. It will be necessary in order to bring the subject within limits, to confine myself chiefly at this time to the consideration of this class of facts and to the results and laws connected with them.

I shall proceed therefore to consider the subject under the following heads:

1. The Instruments for determining depths and temperatures and for obtaining specimens of the bottom.
2. The plan of research.
3. The method of discussion of the results.
4. The results, consisting of type-curves of the law of change of temperature with depth, at several characteristic positions. Type-curves showing the distribution of temperatures across the stream, represented by two sets of curves, one in which the variable temperatures at the same depth is shown, and the other in which the variable depth of the same temperature is represented. Upon the diagrams showing these latter curves, the figure of the bottom of the sea is given, where it has been obtained.

Discussion in regard to the cold wall, which is one of the most interesting features of the approach to the Gulf Stream.

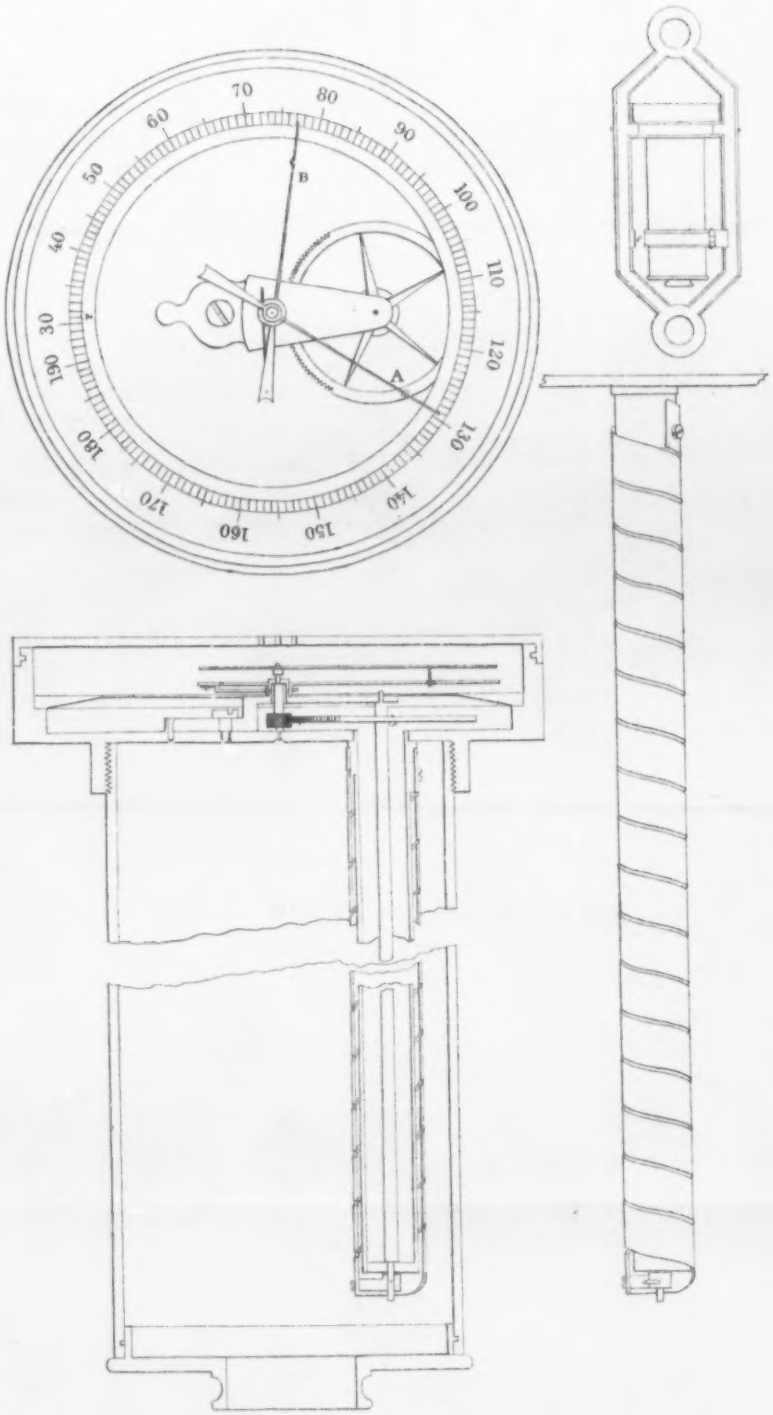
5. The limit of accuracy of the results.
6. The figure of the bottom of the ocean below the Gulf Stream.
7. The general features of the Gulf Stream as to temperature.

These points are illustrated by diagrams, enabling the eye to follow the results as they are stated.

I. Instruments.

1. *For Temperatures.*—The instrument for determining temperatures should fulfill the two conditions of registering its indications and of being unaffected by pressure. The common mercurial thermometer, while it answers perfectly for the determination of temperatures at the surface, fails in both the conditions stated. The ordinary self-registering thermometer, or self-registering metallic thermometer, in the watch form, as made by Breguet, Montandon, and Jürgensen, when provided with a suitable cover to protect it from pressure, answers a good purpose, and has been extensively applied in the course of the observations. As

Plate IV.



SAXTON'S METALLIC THERMOMETER.

For Deep Sea Temperatures

a rule it is only the minimum temperature thermometers that must be used, as the temperatures decrease generally in descending. An ordinary self-registering minimum thermometer placed in a glass globe, was successfully used by Commander Charles H. Davis, and by Lieut. G. M. Bache. It has the disadvantage of taking the temperature slowly, and of being inapplicable below a certain depth. Small hollow cylindrical brass vessels which were divided in two parts closely fitted by grinding, and within which the Breguet thermometers of the watch form were placed, were an improvement upon the glass globe, as taking the temperature of the sea more rapidly, but besides the difficulty of making the joint tight, they were crushed by the pressure, at even moderate depths. The substitution of a globe, for the cylinder, extended the range of these instruments, but the thermometers were often crushed or injured by the access of sea-water to the interior of the globe. Six's self-registering thermometers as bearing considerable pressure without injury and without rendering the indications erroneous, and as requiring no case to enclose them, except to prevent breaking from accidental knocks in handling, are very useful. They are still favorites with many of the officers, though others complain of their great liability to derangement, especially if the mercury is not perfectly clean, when the mercurial column easily separates and some skill is required to bring it together. These instruments are from their cheapness still furnished to the parties and are used successfully at depths reaching about one hundred fathoms, and on occasions, considerably lower. Keeping them in order requires the skill of an experimenter, rather than that of an observer, and hence they do not satisfactorily fulfill the conditions of the problem. The metallic thermometer of Joseph Saxton, Esq., of the U. S. Office of Weights and Measures, is a compound coil resembling somewhat the well known instrument of Breguet. In its construction, two stout ribbons, of silver and platinum—carefully united by silver solder to an intermediate thin plate of gold—are coiled with the more expansible metal in the interior. The gold serves to prevent the tendency of the silver and platinum to separate. The lower end of this coil is fastened to a brass stem passing through the axis of the coil, while its upper end is firmly attached to the base of a short cylinder. The whole motion of the coil as it winds and unwinds with variations of temperature, thus acts to rotate the axial stem. This motion is magnified by multiplying wheels contained in the short cylinder at top, and is registered upon the dial of the instrument by an index, which pushes before it a registering hand, moving with sufficient friction merely to retain its place when thrust forward by the index hand of the thermometer. These instruments are

graduated by trial. The brass and silver portions receive a thick coating of gold by the electrotype process to prevent the action of the sea-water upon them.

When kept clean by frequent washing in fresh water, and in good order and frequently compared with the standards to guard against accidental derangements, these thermometers answer admirably all the required conditions. The length of the coil measured along its axis should not be less than six inches, as the interposition of wheels to magnify the motion, should as far as possible, be avoided. The water being all around the coil, which is a good conductor, and has a low specific heat, the instrument readily feels the temperature of the part of the sea where it is exposed, and registers it to less than half a degree (say 0·2) with certainty. The box which covers the coil and indicating part of the thermometer is merely to protect it from accidental injury, and is open so as to permit the sea-water to pass freely through it. Plate IV gives a view of Saxton's metallic thermometer, and of its various parts in detail. Although there seemed no reason to doubt that this instrument was free from any effects of pressure, it was deemed desirable to actually try it by extreme pressure and a series of experiments made by J. M. Batchelder, Esq., showed that at pressures less than that corresponding to 600 fathoms, the effect was less than one degree (0°·25 to 1°) and at pressures from 600 to 1500 fathoms the change amounted to little more than from 7° to 9° Fahr., the index returning when the pressure was removed. For great depths the effects of pressure must be ascertained, as it is specific in each instrument and probably depends chiefly upon some mechanical defect in the construction, perhaps in the soldering.*

The apparatus used in these experiments on the effect of pressure, was a very ingenious one for testing hydraulic engines by Mr. Thomas Davison of the Novelty Iron Works of New York. Fig. No. 12, Plate IV.

2. *For Depths.*—Where the depth becomes considerable the usual sounding line fails entirely to give it, especially if there is a current and more especially if there is besides, a counter-current. The amount of "stray line" is very variable. This subject has been ably examined of late years by Commanders Maury and S. P. Lee, Lieuts. Berryman, Brooke and others of our navy, and by Commander Dayman and others of the British navy, and especially by Prof. Trowbridge of the Coast Survey in his memoir read before the Association ("Deep Sea Soundings," by W. P. Trowbridge, Assistant U. S. Coast Survey,) at the meeting in Baltimore and re-published in the American Journal of Science and Arts, vol. xxviii for the year 1858.

* Gulf Stream Explorations; Third Memoir Proceedings Amer. Assoc. Adv. Sc., 13th Meeting, Springfield, 1859, and this Jour., [2], vol. xxix, 1860.

The use of Ogden's or Ericcson's leads to 100 fathoms is still continued by some of the officers of the survey, though, at such depths, nothing better than the common sounding line is in fact required. Massey's lead with Woltman's wheel, as an indicator. has been extensively used of late years. Mr. Saxton's indicator is more simple than Massey's, but acts upon the same principle. To remedy the defect of the turning of the cord of the lead line, two indicators are applied, one on each side of the axis. Prof. Trowbridge's lead modified somewhat from that described at the last meeting of the Association in Baltimore, has recently been tried with good success by Lieut. Comdg. Wilkinson in the last soundings across the Straits of Florida for the telegraph to Havana. The most reliable observations heretofore made in the Coast Survey have been with Massey's indicator, the errors are not such as to affect the development of the laws of change at the moderate depth reached in most of the observations, and at great depths the changes are very slow. The new apparatus has the advantage of saving a great deal of time and therefore inaccuracies from change of position during the sounding are avoided.

3. *For obtaining specimens from the bottom.*—The only satisfactory test of having reached the bottom of the sea at considerable depths being the bringing up of a specimen, this has been a subject of constant study with us. The different instruments invented by Lieut. Stellwagen, Commander Sands, Lieut. Craven, Lieut. Berryman, Lieut. Brooke and other officers of our navy, are all in use for different kinds of bottom, and according to the preference given by different hydrographic chiefs. The one most commonly used in these explorations has been Lieut. Stellwagen's invention; a cup placed below the sounding lead, covered by a dick or valve of leather which slides up the stem of the cup and opens when the lead is descending, closing when it is raised. The weight of the lead and the turning of the cord generally suffice to sink the cup into the bottom, filling it, and when the valve is made to close tightly by a piece of flexible leather below the stiff disk, the specimen is not washed out as the lead is drawn up. In Commander Sands' sounding apparatus a spring keeps an outer cylinder over an opening in an inner hollow one, until it reaches the bottom, when the outer cylinder is forced upwards and the opening at the side of the inner one, which, having a conical termination, penetrates the bottom, permitting a specimen of the bottom to pass in. On raising the lead the spring forces the outer cylinder over the opening, preventing the specimen from being washed out. The only very deep soundings being, as a general rule, in soft bottom, Sands' specimen-cylinder is admirably adapted to that class of work.

II. Plan of the Work.

The plan of the work was simple. The temperatures were to be ascertained at various depths, at different distances from the coast, on sections as nearly at right angles with the stream as practicable, the sections starting from some point well known in position. The temperatures were to be taken at distances diminishing as the changes of temperature were more rapid. So in regard to the depths, the observations were to be multiplied in the strata of rapidly varying temperatures near the surface. So in regard to position, when the cold water near the coast was rapidly exchanging for the warm water of the Gulf Stream, the sections diminishing in distance as the source of the warm water was approached.

The vessel's position was determined with reference to some prominent point, Sandy Hook, or Cape May, for example, the course run was perpendicular to the supposed axis of the stream, S.E., several positions were taken up in succession and at each the temperatures ascertained at the surface, at 5, 10, 15, 20, 30, 50, 100, 200, 300, 400, 600 fathoms, or depths found to apply more satisfactorily under the general rule, to the position and section. Having crossed the stream any position found to be desirable, could be assumed on returning, and the extreme position reached was verified by the return to the coast.

The summer season was selected for the standard observations for various reasons, but chiefly for two, namely, that the weather permitted more accurate work, and the phenomena were more likely to be those of equilibrium, when the surface water was more slowly changing its temperature. Our little vessels could not, without considerable danger, be exposed to the roughness of the wind and water in the Gulf Stream in winter, and when we attempted comparative winter observations, disappointment was often the result. The loss of one valuable officer and ten of his crew, and the extreme peril of another in autumnal explorations of the stream, has but too fully justified these precautions. The propriety of selecting the summer for making the observations was completely proved by the success in determining the laws of temperature.

These observations were but incidental to the hydrography of the coast, and hence were prosecuted only when means could be spared from other more pressing and regular parts of the work. It was only a favorable conjuncture with regard to officers, means, weather, adaptation of vessel, and the like, which gave results even when attempted. Too much credit cannot be assigned to those who have succeeded in this laborious and perilous work, and their names have been kept in close connection with their results, whenever and wherever brought before the public, and they have been carefully preserved in the archives

of the Survey. Charles H. Davis, George M. Bache, S. P. Lee, Richard Bache, John N. Maffitt, T. A. Craven, Otway H. Berryman, B. F. Sands and John Wilkinson make up the list of our successful observers in this field within the last sixteen years. Their names you will see attached to the sections run by them on the general chart of the Gulf Stream presented to you this evening.

The first was run in 1844, from Nantucket south and eastward, by Commander C. H. Davis, now the accomplished Superintendent of the Nautical Almanac, and the last in 1860 by Lieut. John Wilkinson, from the Tortugas, southeast to the coast of Cuba. The work still goes on perseveringly.

The number of sections run has been fourteen, the number of positions on these sections occupied 300, and the number of observations made for temperature 3600. The limits below which the stream and the adjacent waters have been explored for temperatures are from latitude 23° N., to 41° N., and from longitude 83° W. to 66½° W. from near Havana to near Cape Cod, and from the Tortugas to 9½° E. of Cape Henlopen. The distance along the axis of the Gulf Stream to the most northeastern point in the North Atlantic, measures nearly 1400 nautical miles.

III. Method of Discussion of the Results.

These have generally been discussed by diagrams, sometimes by analytical formulæ; the former method is generally best adapted to the character and degree of accuracy and circumstances of the observation; the diagrams finally adopted after trials were chiefly of three different kinds, one for the discussion of the change of temperature with depths, the two others for the change of temperature with position as well as depth. Of the first of these diagrams Nos. 1 and 2, Plate I, are specimens. The depths constitute the ordinates and the temperatures the abscissæ of a curve, showing the law of change of temperature with the depth. Upon the horizontal lines at the top of the paper the temperatures from ten degrees to ten degrees Fahr. are written and on the vertical line at the side, the depths. The separate observations being represented by dots; the curve is drawn with a free hand among them.

The next two classes of diagrams give the distribution of temperatures across the sections. In the first the temperature corresponding to the same depth; in the second the depths corresponding to the same temperatures. In this latter the figure of the bottom is shown when ascertained. In both classes the distances from the cape, or headland, city or inlet, which is the origin of the section is marked, and the several positions occupied for observing, so that the abscissæ of the curve are the distances from

the point of beginning. In the first (see diagram No. 4, Plate I,) the temperatures are marked on the vertical lines at the left side of the diagrams, the ordinates of the curves thus corresponding to temperatures. In the second (see diagram No. 9, Plate I,) the depths are similarly written, the ordinates thus corresponding to depths. The notes or legend, show in the first case to what depths the curves correspond and in the second to what temperatures. The observations at each position being plotted according to its temperature or depth in the two classes of diagrams, the curve is drawn with a free hand among the points.

It should be observed that the discussion of each season's observations was in general made separately, and that the result of one, two or three seasons, grouped, were announced separately, leaving to the new observations to confirm, or refute, the conclusions drawn. It is a remarkable fact that with such difficulties in the way, in the character of the phenomena to be observed, in the diversity of seasons and of observers, the phenomena have always been readily deducible from the observations, and that the separate discussions have been confirmations, the following of the preceding; in short that the nature of the medium in which the work has been performed in its relations to heat, has more than compensated for other difficulties and that the results are more accordant than the elaborate ones obtained from the progress of temperature below the surface of the ground by the experienced and skillful observers who have made them. Few observations have been rejected in the whole series.

I need not notice special diagrams which will be explained when your attention is called to them.

When the character of the diagrams to be made had been definitely fixed, they were prepared under the direction of the chiefs of the parties, so that I was relieved of the personal labor of representing the results. In the subsequent general discussion I was greatly assisted by Prof. Pendleton, U. S. N. and by Prof. W. P. Trowbridge, Assistant U. S. Coast Survey, who has made a general review of the whole of the results preparatory to their publication in a volume of the Records and Results of the Coast Survey.

IV. Results.

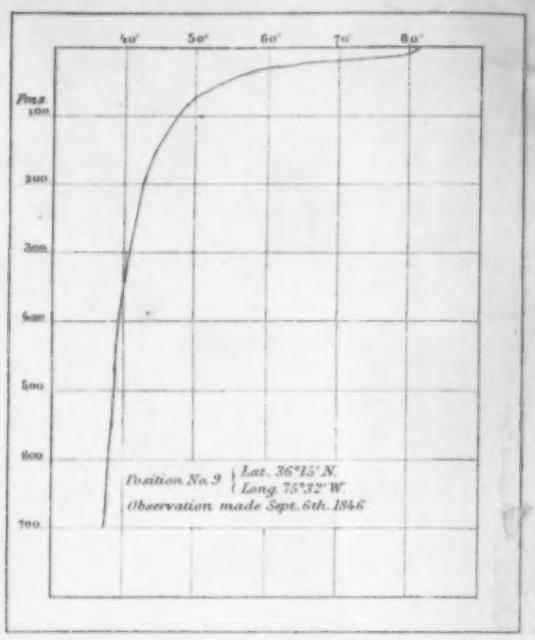
1. *Type-curves of law of temperature with depths at the most characteristic positions.*—The two most characteristic positions are in the cold current between the land and the Gulf Stream and in the axis of the stream itself.

1. Diagram No. 1, Plate I, is a specimen of the type-curve in the cold current. The long tongue from the surface to about 50 fathoms in depth is the overflow of the warm water of the Gulf Stream, the temperature varying from 81° to about 55°. The

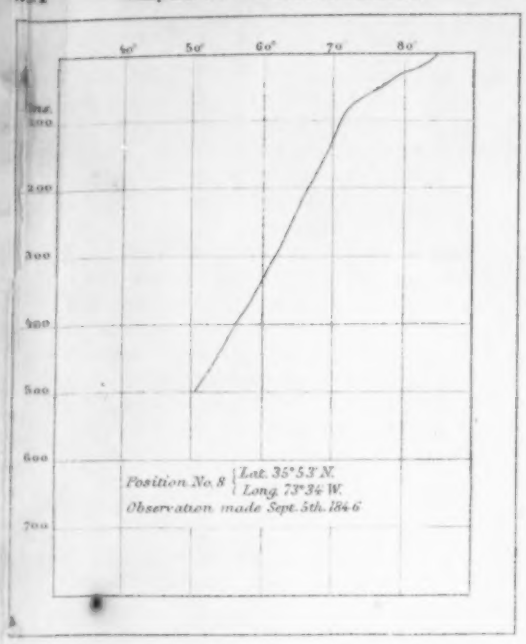
Plate I

SECTION OFF CAPE HENRY

No.1 *Temperatures observed at Position No.9*



No.2 *Temperatures observed at Position No.8*



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DIAGRAMS SHOWING TH

of the

GULF STREAM EXPE

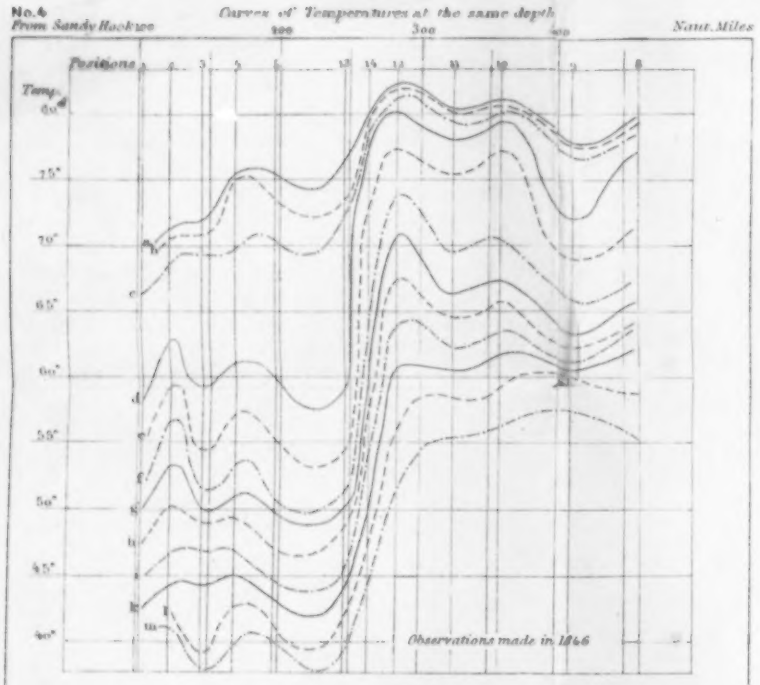
From

Observations made in 1845 '46

1854

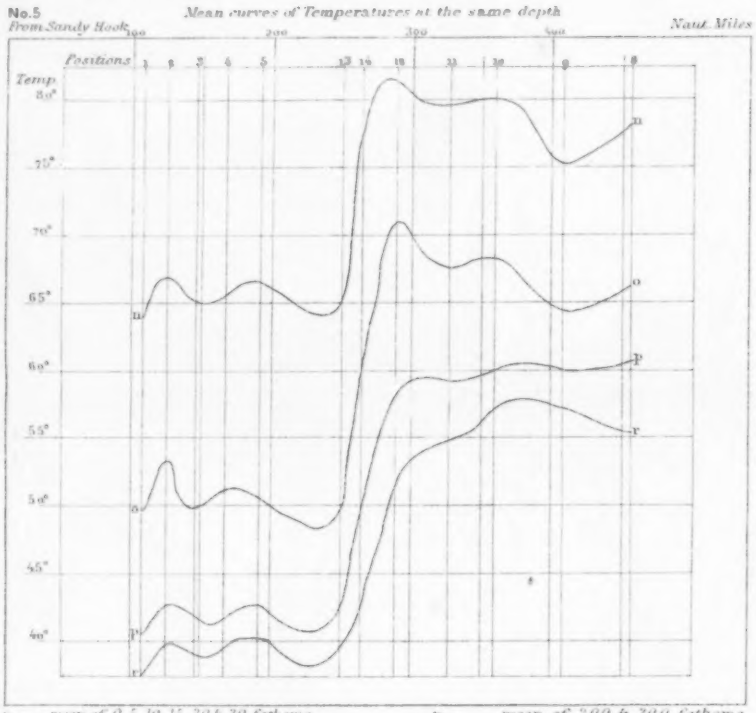
SECTION OFF SANDY HOOK

No.4 *From Sandy Hook 100* *Curves of Temperatures at the same depth* *Naut. Miles*



a — surface
b — 5 fathoms
c — 10 "
d — 20 fathoms
e — 30 "
f — 50 "
g — 70 fathoms
h — 100 "
i — 150 "
k — 200 fathoms
l — 300 "
m — 400 "

No.5 *From Sandy Hook* *Mean curves of Temperatures at the same depth* *Naut. Miles*

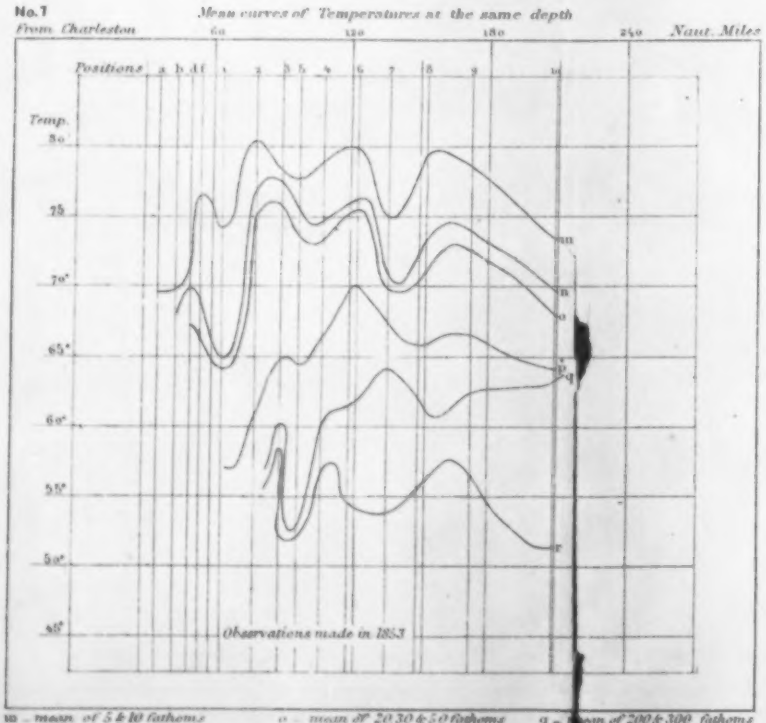


n — mean of 0, 5, 10, 15, 20 & 30 fathoms
o — " " 40, 60, 80 & 100 "
p — mean of 200 & 300 fathoms
r — " " 400 "

No.6

SECTION OFF CHARLESTON

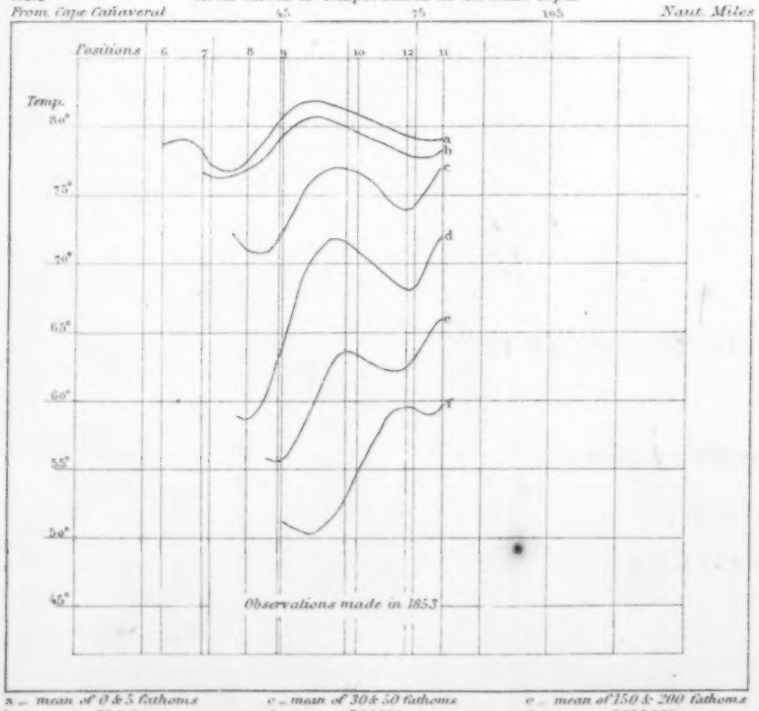
No.7 *From Charleston* *Mean curves of Temperatures at the same depth* *Naut. Miles*



m — mean of 5 & 10 fathoms
n — " " 20 & 30 "
o — mean of 20, 30 & 50 fathoms
p — " " 70, 100 & 150 "
q — mean of 200 & 300 fathoms
r — " " 400 "

SECTION OFF CAPE CAÑAVERAL

No.8 *From Cape Cañaveral* *Mean curves of Temperatures at the same depth* *Naut. Miles*



a — mean of 0 & 5 fathoms
b — " " 10 & 20 "
c — mean of 30 & 50 fathoms
d — " " 70 & 100 "
e — mean of 150 & 200 fathoms
f — " " 300 & 400 "

No.9

Electrotype Copy No.1 by G.Mathiot U.S.C.S.

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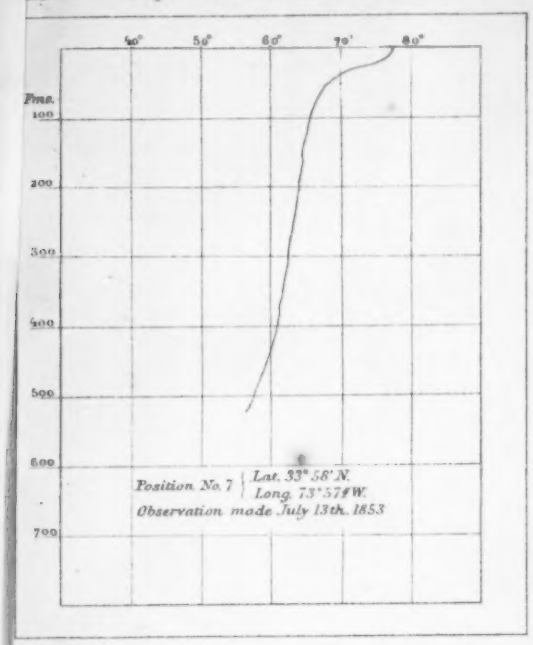
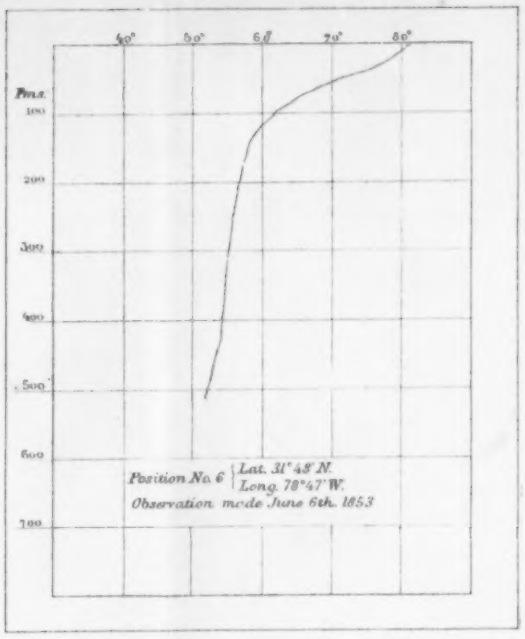
SECTION OFF CAPE HATTERAS

o.3 *Temperatures observed at Position No.7*



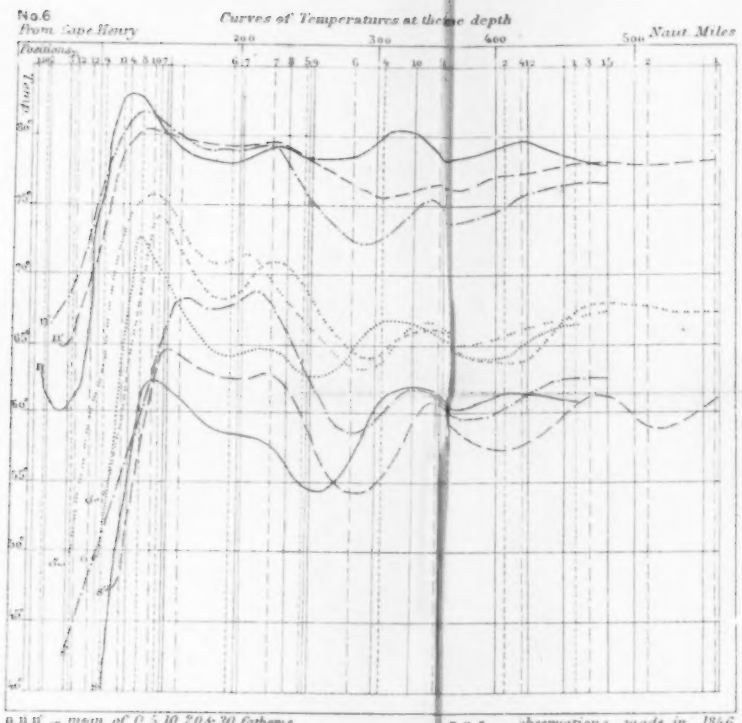
SECTION OFF CHARLESTON

No.3bis *Temperatures observed at Position No6*



SECTION OFF CAPE HENRY

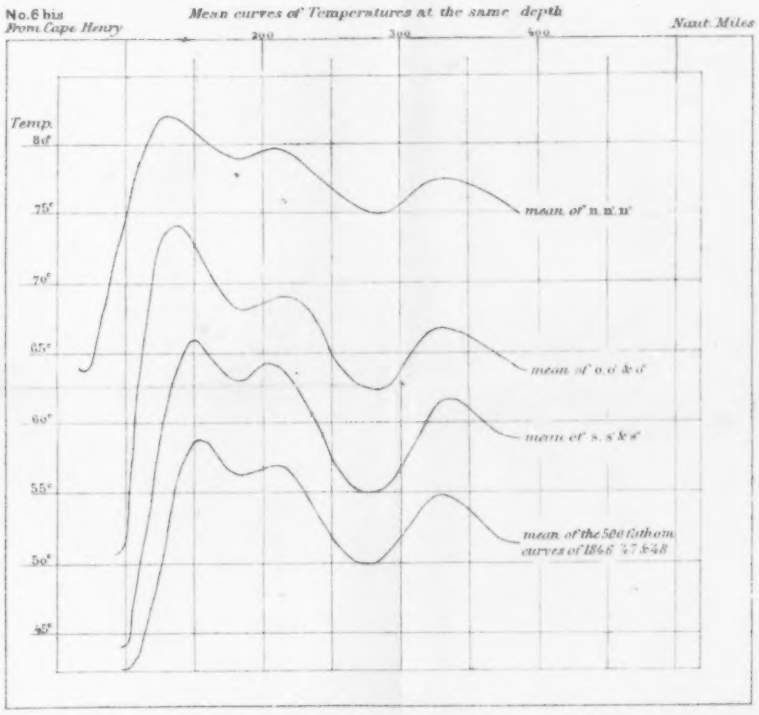
No.6 *Curves of Temperatures at the same depth*



D.D.D. – mean of 0.5.10.20 & 30 fathoms
o.o.o. – " – 50.70.100 & 150 "
s.s.s. – " – 200.300 & 400 "

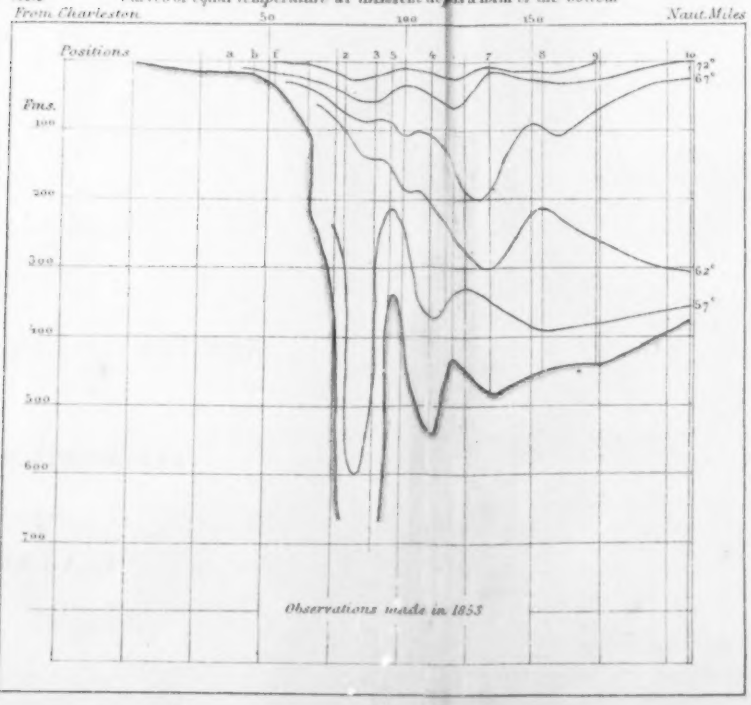
D.O.S. – observations made in 1846
D.O.S. – " " " 1847
K.S.S. – " " " 1848

No.6 bis *Mean curves of Temperatures at the same depth*

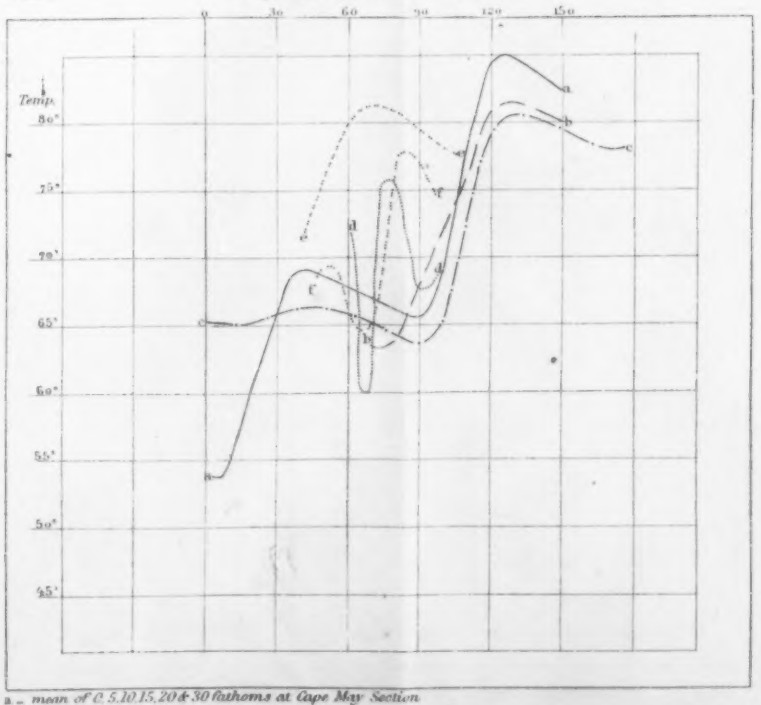


SECTION OFF CHARLESTON

No.9 *Curves of equal temperature at different depths & form of the bottom*



No.10 *Comparative curves of the cold wall*



a – mean of 0.5.10.15.20 & 30 fathoms at Cape May Section
b – " " 0.5.10.15.20 & 30 " " Cape Henry Section 3 years
c – " " 0.5.10.15.20 & 30 " " Sandy Hook "
d – " " 30 & 50 " " St. Simons "
e – " " 0.5.10.15.20 & 30 " " Cape Fear "
f – " " 20 & 30 " " Charleston "

temperatures in the mass of water from 50 fathoms down to 500 fathoms are just such as would take place in a mass of water heated by conduction from the surface, the law is that of a logarithmic curve, in which the conducting power of sea water is the modulus of the system.

A comparison of many of these curves with the logarithmic form showed that it was applicable to them within the limits of the probable error of the observations. Taking the warm stratum from the Gulf of Mexico above and the cold polar stratum below, the mass of the water between is heated by conduction. The bottom of the sea has not been reached under the axis of the Gulf Stream, north of Cape Lookout on the North Carolina coast.

This form of curve was deduced in 1844 from the observations of Commander Charles H. Davis and was the first discovery made in connection with the then recently commenced systematic exploration of the Gulf Stream by the Coast Survey.

2. Nos. 2, 3, and 3 bis, Plate I, are specimens of the type-curve in the Gulf Stream, taken from the sections off Cape Henry, Cape Hatteras and Charleston, being characterized by the comparatively short beak or projection and the persistence of the higher temperature to great depths as 55° to 425, 450, 550 fathoms giving the peculiar shape to this curve between 50 and 500 fathoms.

II. Type-curves of distribution of Temperature across the Stream.

(*a.*) *Curves of temperature at the same depths.*—The sections made are the following, beginning the enumeration at the Gulf of Mexico: 1. Tortugas to Havana. 2. Sombrero Key to Salt Key. 3. Carysfort, L. H., to Cuba. 4. Cape Florida to Bemini. 5. Off Cape Cañaveral. 6. Off St. Augustine. 7. Off St. Simon's, Georgia. 8. Off Charleston. 9. Off Cape Fear. 10. Off Cape Hatteras. 11. Off Cape Henry. 12. Off Cape May. 13. Off Sandy Hook. 14. Off Cape Cod, being on the average one to each hundred miles along the axis of the stream. These are marked on the general chart, Plate III, the names of the explorers being stated in the column which gives the point of origin of each section.

The Sandy Hook curves, Nos. 4 and 5 Plate I, are among the best of the type-curves of temperature at the same depth, though among the earliest determined. The overflow of the Gulf Stream into the long space occupied by the cold current between it and the shore, mixing in a degree with the cold water, is well shown by the curves *a*, *b* and *c* at the surface, 5 and 10 fathoms, and the still greater admixture with the cold water at 20, 30 and 50 fathoms (*d*, *e*, *f*.) The whole space from the shore to 240 miles, is occupied, however, with comparatively cold water. Then is

met the sudden rise to the Gulf Stream shown especially below 50 fathoms and termed so appropriately by Lieut. George M. Bache the "cold wall," that navigators have not hesitated to receive the term into use; next the hot water of the Gulf Stream, rising to a maximum of 82°, then falling to a minimum of 80°, rising to a second maximum of 81¼°, falling to a second minimum of 78° and rising from this toward a third maximum. With these results the curves at 5 and 10 fathoms and those at 20, 30, 50, 70, 100 and 150 fathoms agree and, with characteristic differences, those of 200, 300, 400 and 500 fathoms.

The cold wall at 20 fathoms shows a rise of 19° in 25 miles, three quarters of a degree to a mile, and at 200 fathoms of 16°, in the same distance; at the surface it is nearly 8° in 50 miles. The cold water between the Gulf Stream and the shore has two well marked maxima and two minima in it, of which one seems to correspond in position to the sudden deepening of the water 100 miles from Sandy Hook, as shown by the Coast Survey off-shore chart between Gay Head and Cape Henlopen.

These results are more distinctly seen by grouping the curves into natural groups and taking the mean of their indications. Diagram No. 5 Plate I, gives the group of six curves from the surface to 30 fathoms, of four curves from 40 to 100 fathoms, both inclusive of 200, 300, and the single curve at 400.

Similar groups are shown on Diagram No. 6, Plate I, from Cape Henry, the cold wall, three maxima of temperature and three minima being very distinctly seen. The results of three different explorations of this section, by three different officers, in three different years, are shown upon the same diagram. The coincidence of result could hardly be better. The average of the whole of the observations is shown in No. 6 bis, Plate I.

The cold wall here gives a change of 22½° in 50 miles from the curves between 0 and 30 fathoms and 18° in 50 miles in the mean of 200, 300 and 400 fathoms.

The average of the three years comes out beautifully on Diagram No. 6 bis, Plate I. The Charleston curves are shown upon No. 7, Plate I. They are less regular than those just given, for reasons which will appear, when I come to speak of the second class of diagrams.

The conclusions deduced from the examination of all the sections between Cape Florida and Sandy Hook is, that the Gulf Stream is divided into alternate bands of hot, or warm and cool or cold water, the most distinct of which is that containing the axis of the Gulf Stream.

That between the stream and the coast there is a fall of temperature so sudden that it has been aptly called the cold wall, less distinct at the surface and where the overflow from the Gulf Stream passes furthest toward the shore, but still distinctly marked even at the surface.

Navigators have noticed these changes of temperature and have supposed themselves at each occurrence of warmer water to be in the hottest water of the stream and so have been greatly embarrassed and have deemed the phenomena and limits of the Gulf Stream to be very irregular.

The cold water between the Gulf Stream and the shore has also bands less regular than those beyond the axis of warmer and cooler water.

The intrusive cool water in the Gulf Stream on the Sandy Hook section was distinctly recognized in 1846 by Lieut. Geo. M. Bache, who from the facts observed, supposed it to represent a division of the warm water of the stream into two branches.

Passing through the Straits of Florida between the keys and reefs and the coast of Cuba we have after going beyond Cape Florida, a different type-curve. The cold wall is less distinctly marked and the rise of temperature is less marked. It rises however to an axis near the coast of Cuba. Throughout the length of the Strait there is but one maximum of temperature and the bands belonging to the Atlantic regimen do not occur in the straits. (See diagrams Nos. 3, 4, 5, 6, Plate II.) The cause of this change of regimen will be seen in presenting the other form of diagram.

(*b.*) *Curves of depths at the same temperature.*—I have selected curves from the southern portions of the work, partly because the bottom has been struck in the sections and the diagrams show its sections as well as those of the stream, and partly to show how fully the deductions in regard to the divisions of the stream, apply to these, as well as the more northern sections. The Charleston section of Lieut. Maffitt is given on diagram No. 9, Plate I. The surface curve, notwithstanding the disturbance by a storm, shows the cold wall, (see also No. 7) the axis and two other maxima, the corresponding minima, a maximum within the cold current which is not therefore, as has been supposed, cut off at Hatteras, the curve of 72° reaching to the coast and 77° nearly reaching it. The Cape Florida diagrams (Nos. 3 and 7, Plate II.) give two maxima with indications of a third and the corresponding minima. The cold wall cannot be recognized upon it, probably for the want of one or two, more positions.

The form of the bottom delineated on these two sections, namely the Charleston and Cape Florida sections, is remarkable and applies to the sections between them as far as explored. First is a gentle slope, then a sudden descent, a second steep pitch to a considerable depth, a range of hills, a valley and a second range.

The correspondence of these features with the bands of temperature is plainly marked. The cold water lies in the valleys and passing along the bottom rises upon the tops of the hills. The discovery of this range of hills was made at nearly the same time

by Lieut. Maffitt on the Charleston section and by Lieut. Craven on the St. Simon's section. Diagram No. 9, Plate I, shows this connection in a very striking manner as does also No.7, Plate II, and the figure of the bottom of the straits of Florida, shows why there are no bands formed prior to passing Cape Florida, in other words, why the regimen of the stream is different in the straits and in the Atlantic. In the straits we see (No. 9, Plate II) that after leaving the United States shore and the comparatively flat surface extending to the reefs, there is a rapid descent toward the Cuban side of the strait, the axis of the Gulf Stream being found in the deep hollow of that side of the strait.

These results, with a more elaborate discussion of them, were presented at the last meeting of the Association. It would seem from the configuration of the bottom, that the cold stream at the bottom of the straits of Florida divides, one portion passing to the north and west into the Gulf of Mexico and the other around the western end of the Island of Cuba. That the polar stream still occupies the bottom of the strait is shown by temperature of 35° Fahr. being reached at 600 fathoms from the surface off Havana.

Do these bands correspond throughout their length to the form of the bottom of the sea? This is not yet made out, many as have been the attempts to reach the considerable depths off the more northern sections. Three officers have attempted to sound out the Cape Cod section, but the cold wall is all that has been reached thus far. The range of hills nearest to the coast, has been traced from the coast of Georgia by Commander Sands to off Cape Lookout.

III. The Cold Wall.

The cold wall extends with varying dimensions and changes of its peculiar features, all along the coast where the stream has been examined. A diagram showing the features of the cold wall on the various Atlantic sections and those of the straits of Florida is given in No. 10, Plate I. Table No. 1 shows the distance of the cold wall from the coast and the dimensions of the Atlantic bands of the Gulf Stream.

The table shows that at Cape Florida and Cape Hatteras the cold wall is nearest to the coast. The distance of the axis of the stream from the coast will be found by adding half the numbers in the second column to those in the first column. It is obvious from these numbers, when taken in connection with the longitudes of the points where the sections originate, that the earth's motion is not the sole determining cause of the direction of the axis of the stream, a result which a more elaborate investigation of the movements from parallel to parallel confirms. In the portions of its course between Cape Florida and Mosquito inlet ($3\frac{1}{4}$° of latitude) the curve is actually slightly to the westward.

TABLE 1.—*Distance of the cold wall from the shore, and widths of the several bands of cold and warm water in the Gulf Stream, measured on the lines of the Sections.*

Names of Sections.	Distance of cold wall from shore in miles.	Width of 1st maximum or warm band.	Width of 2d minimum or cold band.	Width of 2d maximum.	Width of Gulf Stream, proper.	Width of 3d minimum or cold band.	Width of 3d maximum or warm band.	Width of 4th minimum or cold band.
Sandy Hook.....	240	60	30	37	127	60	50	Indef.
Cape May.....	125	55	30	40	125	70	65	70
Cape Henry.....	95	45	32	47	124	80	60	50
Cape Hatteras.....	30	47	25	45	117	37	75	70
Cape Fear.....	60	30	20	37	87	30	60	25
Charleston.....	62	25	15	30	67	26	35	—
St. Simons.....	87	25	13	20	58	25	25	—
St. Augustine.....	70	20	13	12	47	22	20	—
Cape Cañaveral.....	35	20	—	—	35	14	12	—
Cape Florida	10	25	—	—	25	5	—	—

Note.—The width of the bands beyond the 2d maximum, and north of Cape Hatteras are somewhat indefinite.

The table shows a width in the Gulf Stream proper along the Atlantic coast of from 25 miles off Cape Florida to 127 miles off Sandy Hook. The warm water at say fifteen fathoms, is from 30 to 150 miles in width. The stream widens each way from Cape Florida. These several divisions of the Atlantic stream lose a portion of their distinctness as we pass northward and eastward, the stream widening.

IV. LIMIT OF ACCURACY OF THE DETERMINATIONS.

There are two modes by which the limits of accuracy of these results may be tested, by one of which their permanency is also tried. In this latter mode the sections are run over in different years, or in the same year by different officers, so as to connect the observations of one year with those of the next, or of one officer with that of another. Table No. 2 shows that the relative results are reproduced from year to year with less variability than those of the mean temperature of the section ; and hence the permanency of the bands and the possibility of observing them with the requisite precision must be admitted. On the Cape Henry section which was explored three times, the position of the cold wall and of the axis of the stream were reproduced within $5\frac{1}{2}$ miles and those of the succeeding points of maximum and minimum temperatures within $7\frac{1}{2}$ miles. As the positions at sea are liable to an uncertainty of some three to five miles it must be admitted that the permanency of the bands and the accuracy of the observations of them are fully proved.

The Cape Henry section was run over by Lieuts. G. M. Bache, S. P. Lee, and Richard Bache, the Hatteras section by Lieuts. Richard Bache and J. N. Maffit, and the Charleston section by Lieuts. J. N. Maffit and T. A. Craven.

TABLE 2.—*Table showing the probable uncertainty in the determination of maximum and minimum points, by running the same section over in different years by different observers.*

CAPE HENRY SECTION.

Dates and names of observers.	Mean distances from the shore in miles from the curves representing the groups.						
	Cold wall or 1st min	Axis or 1st max.	Second min.	Second max	Third min.	Third max	Fourth min.
Lt. G. M. Bache, 1846	93	135	187	218	2:0	32	369
" S. P. Lee, 1847	91	146	185	215	2·1	33·7	338
" R. Bache, 1848	97	146	180	19	287	3:8	7
Means for three years.	84	142	184	210	279	3 8	370
Probable error for each year.	5·85	4·27	2·42	7·62	11·81	5·71	7·18

CAPE HATTERAS SECTION.

Lt. R. Bache, 1848	—	90	134	162	214	286	355
" J. M. Maffit, 1853	—	75	125	157	211	256	322
Means for two years	—	82	129	159	212	266	338
Probable error for each year	—	6·4	4·3	2·4	1·5	15	16
Means for both sections	5·85	5·3	3·4	5·0	6·4	1·04	1·16

Average uncertainty of maxima and minima, 6·9 miles.
" " cold wall and axis, 5·5 "
" " all the other points, 7·4 "

The other mode of testing the result is by the comparison of the remarkable points in the different sections, each one belonging to a different position and therefore being entirely independent of the other in its determination. It is established as a general law that this cold wall and axis of the hottest water change their position from the surface to the depth of six hundred fathoms slowly and by an ascertained progression, and that the succeeding maximum and minimum points are at the same distance from the shore, nearly, at different depths, or in a vertical line at all the different depths. The positions of these points as shown by the observations at different depths become thus the test of the permanency of their positions and of the accuracy with which they have been ascertained. Table 3 gives the probable error of the mean of the determinations of each point including the cold wall minimum, the axis maximum, and the successive minima and maxima to the fourth minimum inclusive. These results show that the cold wall minimum is ascertained, on the average, within 0·83 mile, the axis maximum within two miles and a half, the second minimum within two miles and a half, the second maximum and third minimum and third maximum, within four miles, and the fourth maximum within eight and a half miles, all being satisfactory except the last, which of course is in reality loosely defined. The Hatteras result for the axis of the stream, makes the probable error considerably larger than it would otherwise be, probably from the

fact that the proximity of the bottom of the sea, makes the result less permanent than in the other cases. Without this result the mean probable error would be 1·1 mile.

TABLE 3.—*Recapitulation, showing the value of the probable error of determination of the bands for each section and the average of the whole.*

Sections.	1st min	1st max	2d min.	2d max.	3d min	3d max	4th min.
	Probable errors.						
Sandy Hook		·75		3·94	7·99		
Cape May	·82	1·25	2·54	1·57		4·03	4·87
Cape Henry, 3 years	·84	·61	·55	1·70	1·06	·94	3·42
Cape Hatteras, 2 years		6·77	6·36	9·31	5·69	6·23	
Cape Fear		1·25			2·98	3·49	13·37
Charleston	1·25	1·57	·72	2·09	2·40	·82	
St. Simons		·74	1·27	·41			
St. Augustine	·52	·51	·44	·44	·55		
Cape Cañaveral	·95	1·69	·39				
Mean probable error	·83	2·49	2·49	4·00	4·01	3·71	8·45

While these results are so permanent, the mean temperatures of the sections change considerably from year to year. The average temperature between the surface and 400 fathoms beyond, or outside of the cold wall on the Sandy Hook section in 1846, was as high as that on the Cape Henry section in 1848, and that on the Cape Fear section in 1853, within a degree of that of the St. Augustine section in 1853, while the Cape Hatteras section in 1848 and in 1853, differed two degrees in mean temperatures. Again the temperatures from the surface to 30 fathoms just below the axis of the stream in the Sandy Hook section in August 1846 was either as high or higher than those on the Cañaveral section in June 1853. In general the Cape May section in 1846 and the mean of the Cape Henry section of 1846, 1847 and 1848 are warmer at the same depths than the sections south of it were in 1848 and 1853.

These results show that there are great changes in temperature from year to year, and probably from season to season. Some progress has been made in connecting these results in a general way with the changes of weather in the Gulf of Mexico.

The depths at which the results are easily determined and where they are characteristic and as permanent as the phenomena permit is thirty fathoms.

V. Figure of the Bottom of the Sea, below the Gulf Stream.

We have seen that in cross sections there is a great resemblance in the bottom of the sea off our coast to the region of land more removed from the coast-line in the interior. The top of the first range of hills, (see Diagram No. 9, Plate I,) is 1500 feet above the valley to the eastward of it, distant 12 miles; and the top of the second range 600 feet above the same valley, distant 15 miles. The first slope is 125 feet, and the second is 40 feet,

to the mile. The bottom of the sea from the Tortugas section to that of Cape Florida, rises from 800 to 325 fathoms, and from the same point descends, in passing northward and eastward. The Cape Florida section showed that there then was present a ridge of comparatively cold water since the division into bands should apply along the stream as well as in the direction of its cross sections. The temperature of 40° is in fact reached on that section at 300 fathoms, and, as well as can be judged from the results in the separate sections there are divisions of this sort. The diagram No. 2, Plate II, shows where the curves of 50° and 45° are found upon the different sections and indicates a rise on the Charleston section and a sharp descent from Charleston to Cape Fear.

VII. General features of the Gulf Stream.

Upon the general diagram now presented to the members, (Plate III,) the general features of the Gulf Stream are represented from the Tortugas to the Cape Cod Section. Passing along the Cuban coast the temperature in June was found to be about 84° or 8° above the mean temperature of Key West, as given by the Surgeon General's report. The current here is feeble, but sufficient to cause it to be sought by sailing vessels making to windward and even by steamers. Issuing from the straits of Bemini, the stream is turned northward by the land which confines and directs its course. Its effective velocity is not derived from difference of temperature, as the observations abundantly show, the greatest relative differences being in fact crosswise of the stream. The direction is here a little west of north and the velocity is from 3 to 5 miles per hour. The temperature bands now begin. The bottom of the sea which was one slope and counter slope, across the Florida Straits, is here corrugated; the depth instead of being unfathomable, as has heretofore been supposed, is but 325 fathoms, in which depth the two currents, from the poles near the bottom and from the Gulf at the top, must pass each other. While the surface water is above 80° that near the bottom is as low as 40°.

The stream just north of Mosquito inlet begins to bend to the eastward of north, and off St. Augustine has a decided set to the eastward. While flowing thus onward the warm water seeks the sides of the channel overflowing towards the coast of Florida, and towards the Bahamas, but not as rapidly as it moves on north. Between St. Augustine and Cape Hatteras the set of the stream and the trend of the coast differ but little, making 5 degrees of easting in 5 degrees of northing. At Hatteras it curves to the northward and then runs easterly, making about 3 degrees of northing in 3 degrees of easting. In the latitude of Cape Charles it turns quite to the eastward having a velocity of between one and one mile and a half the hour.

U.S.COAST SURVE

A.D.BACHE Supdt.

DIAGRAMS SHOWING T

of the

GULF STREAM EXPLOR

From

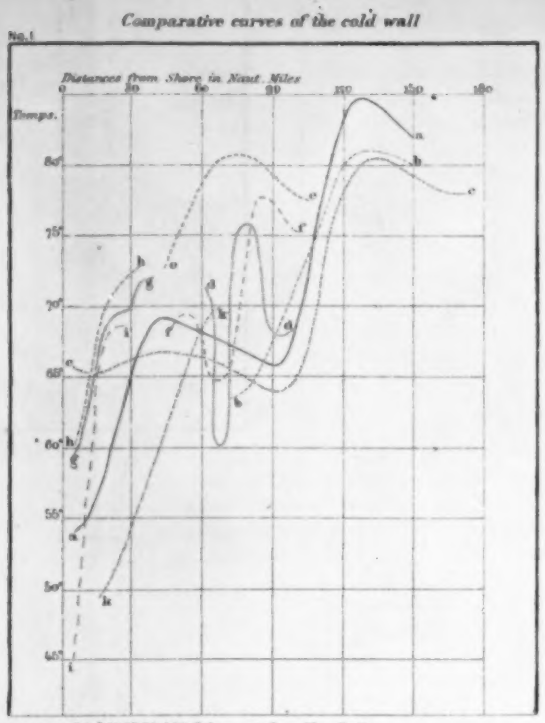
Observations made in 1845 '46 '47 '48 '53

1859

CHART
showing the lines of Sections run in the Straits of Florida

Comparative curves of the cold wall

No.1

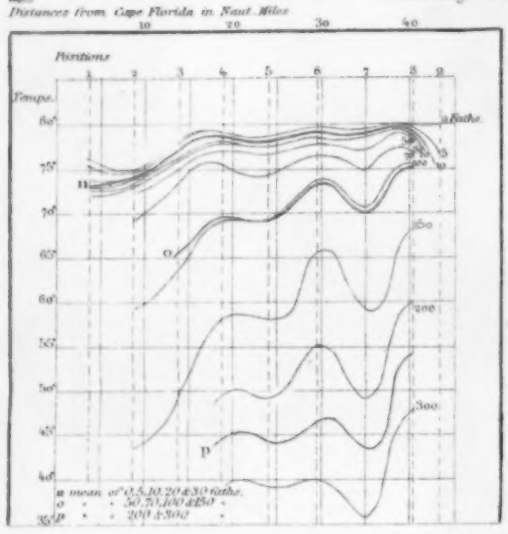


a mean of 0,5,10,15,20 & 30 fathoms at Cape May Section
b " " 0,5,10,15,20 & 30 " " Cape Henry " 3 years
c " " 0,5,10,15,20 & 30 " " Sandy Hook "
d " " 20 & 30 " " St. Simon's "
e " " 0,5,10,15,20 & 30 " " Cape Fear "
f " " 20 & 30 " " Charleston "
g " " 100 " " Cape Florida "
h " " 100 " " Carysfort Lt.Ho. "
i " " 70 & 100 " " Sombrero Key "
k " " 200 " " Tortugas "

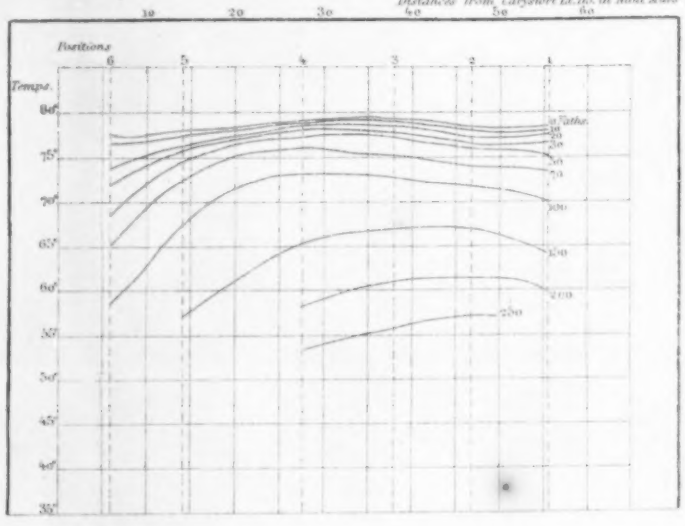
Sections off Cape Florida and Carysfort Lt.Ho. Diagrams of Sections

Showing changes of temperature at the same depth

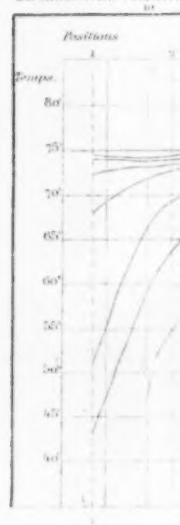
No.3
Distances from Cape Florida in Naut. Miles



No.4
Distances from Carysfort Lt.Ho. in Naut. Miles



No.5
Distances from Sombrero

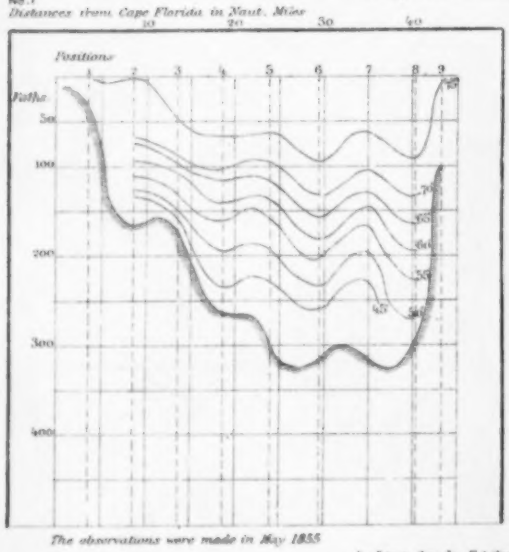


Section 1

Section 2

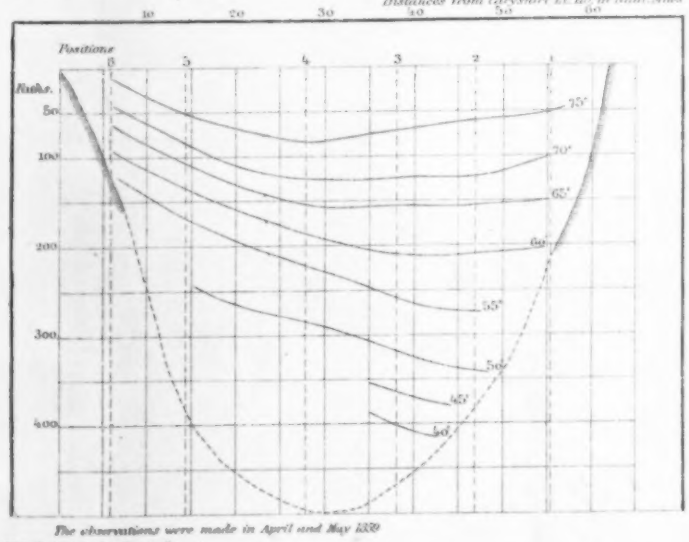
Showing bottom and changes of depth for the same temperature

No.7
Distances from Cape Florida in Naut. Miles



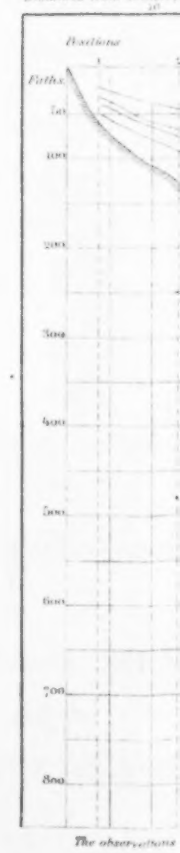
The observations were made in May 1855

No.8
Distances from Carysfort Lt.Ho. in Naut. Miles



The observations were made in April and May 1859
by Lieut. Comdg. T.A.Craven U.S.N. Asst. in the Coast Survey

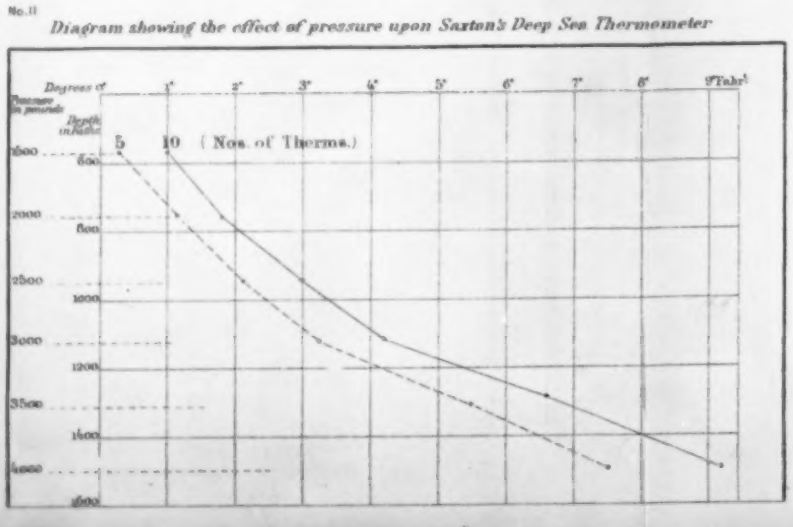
No.9
Distances from Sombrero



The observations

No.11

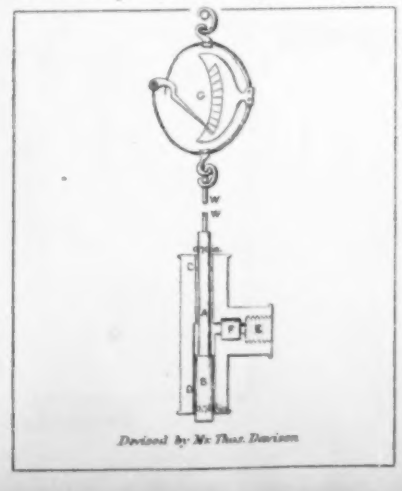
Diagram showing the effect of pressure upon Saxton's Deep Sea Thermometer



GAUGE

No.12

for measuring the pressure in hydraulic cylinders



Devised by Mr. Thos. Davison

SURVEY

E Supdt.

NG THE RESULTS

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XPLORATIONS

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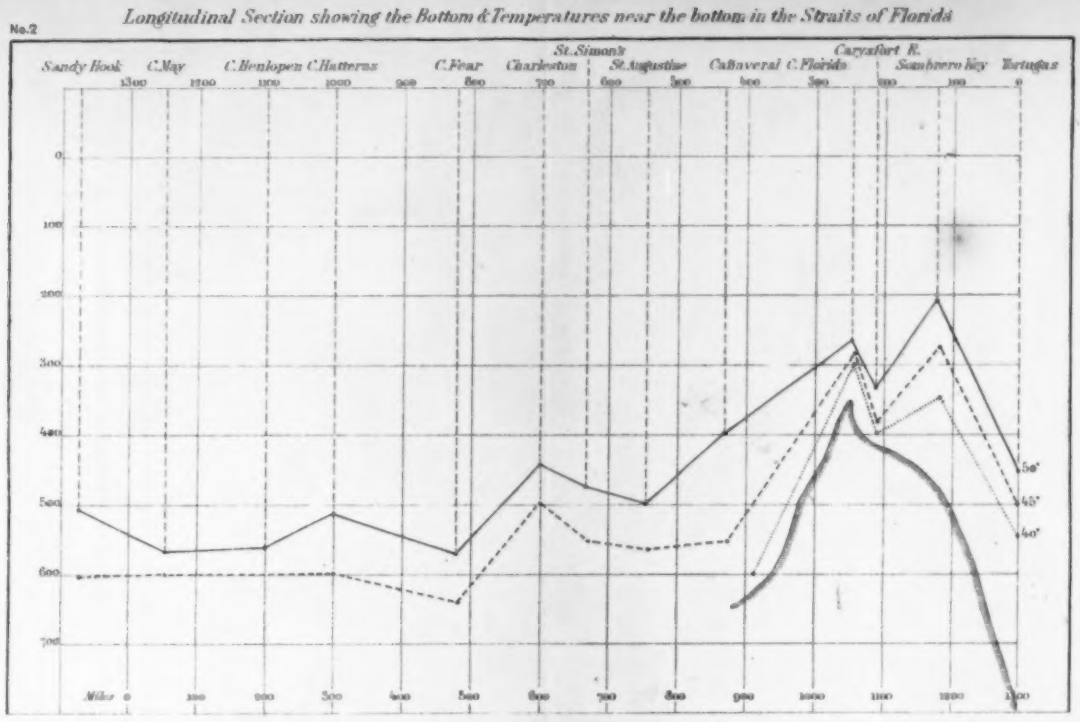
59

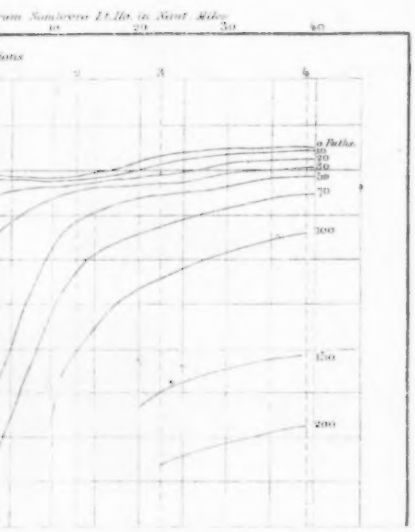
No.2

Longitudinal Section showing the Bottom & Temperatures near the bottom in the Straits of Florida



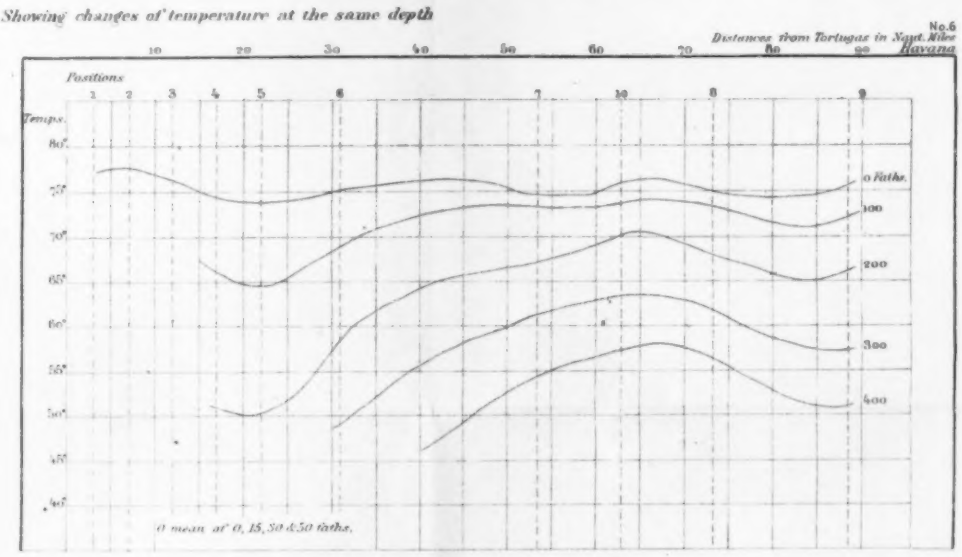
Sections off Sombrero Lt. Ho. and Tortugas. Diagrams of Sections

Showing changes of temperature at the same depth



No.6

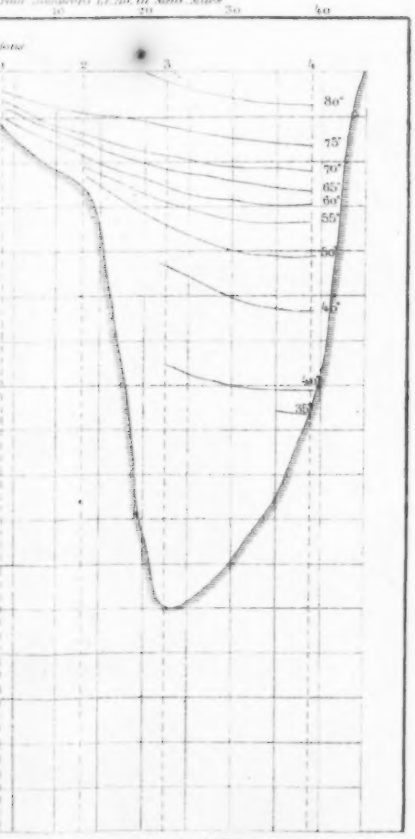
Distances from Tortugas in Naut. Miles



Section 3

Section 4

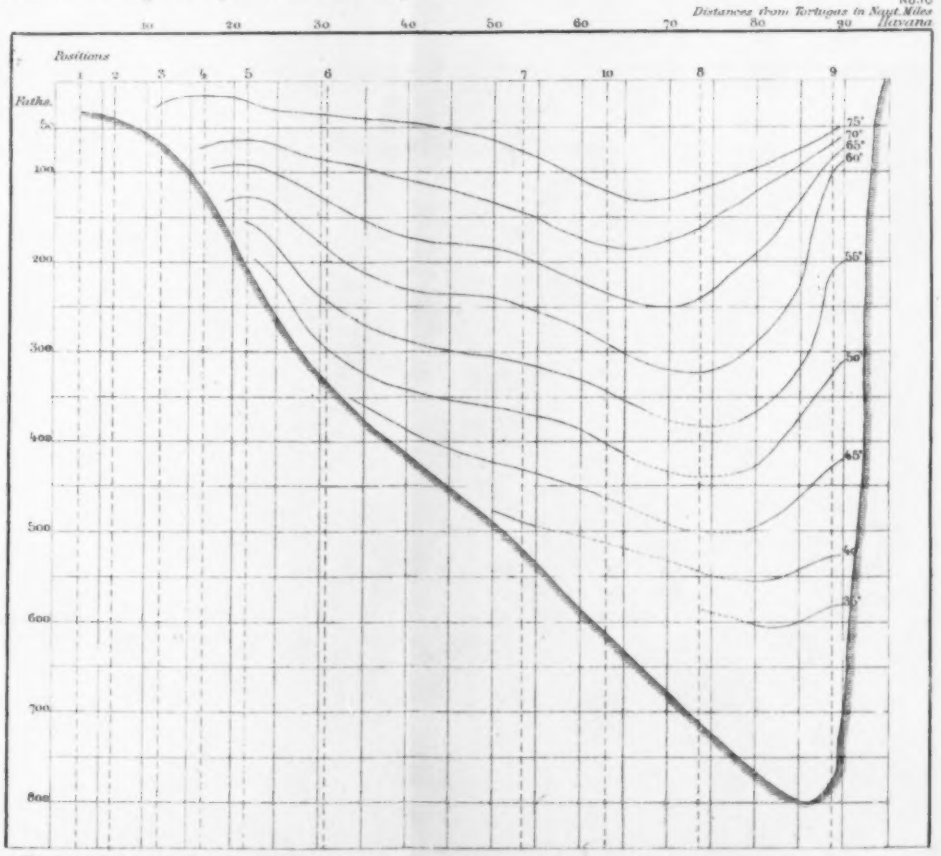
Showing bottom and changes of depth for the same temperature



observations were made in April 1850

No.10

Distances from Tortugas in Naut. Miles



The observations were made in May 1858
by Commander B.F.Sands U.S.N. Asst. in the Coast Survey

Plate III

U. S. COAST SURVEY

A.D. BACHE Supdt.

CHART OF THE GULF STREAM

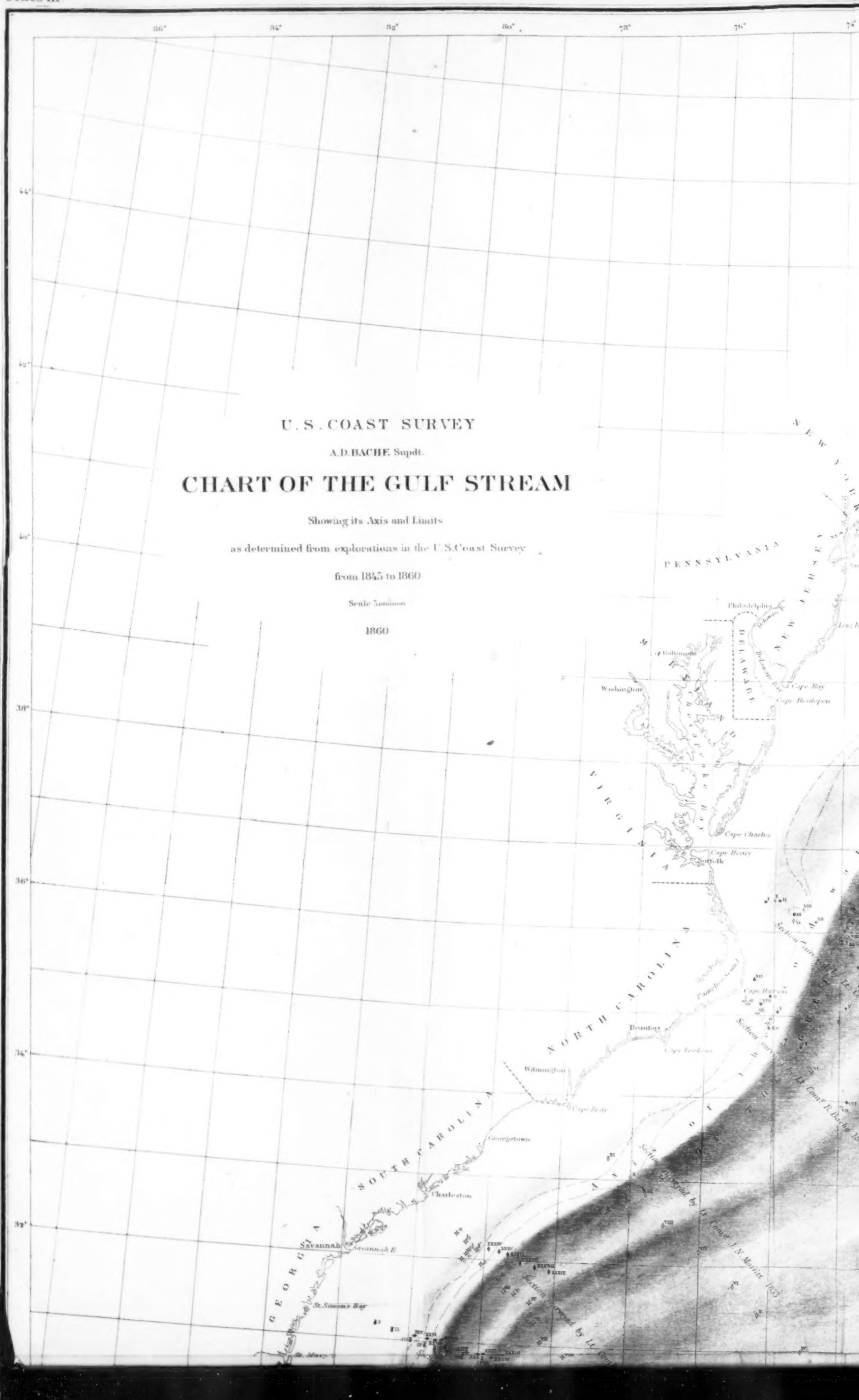
Showing its Axis and Limits

as determined from explorations in the U.S. Coast Survey

from 1845 to 1860

Scale 1:1000000

1860



74° 72° 70° 69° 68° 66° 64° 62° 60°

44° 42° 40° 38° 36° 34° 32°

NEW BRUNSWICK

Northumberland Straits

U.S. Boundary

N. S. C O T I A

Halifax

Sable I. Bank

Portland

Cape Sable

NEW HAMPSHIRE

Newburyport

Jeffrey's Ledge

Eppenuss

Cape Ann

MASSACHUSETTS

Boston

Massachusetts Bay

Stellwagen's Bank

Cape Cod

Cape Cod Bay

Plymouth

Clarks Bank

Georges Shoal

CONNECTICUT

RHODE ISLAND

Hartford

Newport

Nantucket Sound

Martha's Vineyard

Nantucket

Monomoy I.

Mc Blair's Shoal

Gt. Rip

Fishing Rip

Old South Shoal

Davis Bank

Block I.

Montauk Pt.

Long I. Sound

Fire Island

South Beach

Long Beach

Section surveyed by Lieut. Comd^g T. A. Craven 1851

Section surveyed by Lieut. Comd^g C. H. Davis 1845

Section surveyed by Lt. Comd^g Geo. M. Bache 1846

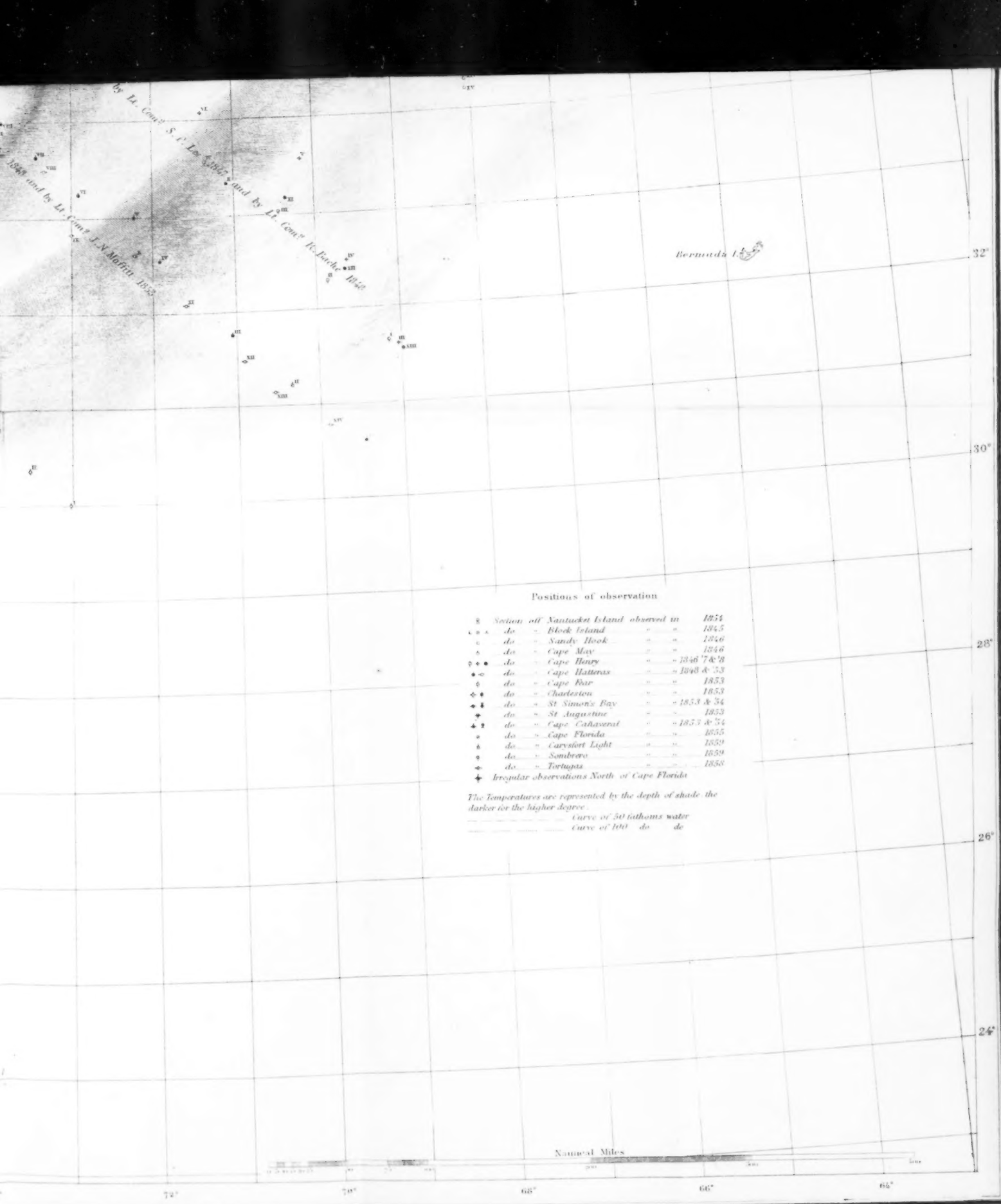
Section surveyed by Lt. Comd^g Geo. M. Bache 1846

Section surveyed by Lt. Comd^g Geo. M. Bache 1846 by Lt. Comd^g S. P. Lee 1847 and by Lt. Comd^g R. Bache 1848

Section surveyed by Lt. Comd^g R. Bache 1844 and by Lt. Comd^g J. N. Maffitt 1853

Bermuda I.

SOUTH CAROLINA
GEORGIA
FLORIDA
Bahama Islands
Georgetown
Charleston
Savannah
Savannah R.
St. Simons Bay
St. Mary's
St. Johns R.
St. Augustine
Appalachee Bay
Cedar Keys
Tampa Bay
Charlotte Harbour
Cape Canaveral
Cape Romano
Cape Sable
Dry Tortugas
Key West
Florida Reef
Salt Key Bank
Havana
Matanzas
Bahia Honda
CUBA
Great Bahama
Great Abaco
N.W. Providence Chan.
Bemini Ids.
Andros I.
Eleuthera I.
San Salvador or Cat
Watlings I.
Rum K.
Great Exuma I.
Great Bahama Bank
Section surveyed by Lt. Comd. R. Rucker 1848 and by
Section surveyed by Lt. Comd. J.N. Maffitt 1853
Section surveyed by Lt. Comd. J.N. Maffitt 1853 and by Lt. Comd. T.A. Craven 1853 & 54
Section surveyed by Lt. Comd. T.A. Craven 1853
Section surveyed by Lt. Comd. T.A. Craven 1853 & 54
32°
30°
28°
26°
24°
84°
82°
80°
78°
76°
74°


by Lt. Com.r S. C. Lee 1845
and by Lt. Com.r T. Lothe 1846
1848 and by Lt. Com.r J. N. Maffitt 1853
Bermuda I.s
32°
30°
28°
26°
24°
Positions of observation
Section off Nantucket Island observed in 1854
do " Block Island " " 1845
do " Sandy Hook " " 1846
do " Cape May " " 1846
do " Cape Henry " " 1846 '7 & '8
do " Cape Hatteras " " 1848 & '53
do " Cape Fear " " 1853
do " Charleston " " 1853
do " St Simon's Bay " " 1853 & '54
do " St Augustine " " 1853
do " Cape Cañaveral " " 1853 & '54
do " Cape Florida " " 1855
do " Carysfort Light " " 1859
do " Sombrero " " 1859
do " Tortugas " " 1858
Irregular observations North of Cape Florida
The Temperatures are represented by the depth of shade the darker for the higher degree.
Curve of 50 fathoms water
Curve of 100 do do
Nautical Miles
74°
70°
68°
66°
64°

Engd by W Ogilvie & App F W Benner

That this curve follows the general sweep of the coast under water, appears most probable, the coast line, the curve of 100 fathoms and the ranges of hills discovered by Lieuts. Maffitt and Craven all seem to indicate it. That the direction of the stream is given in a general way by the configuration of the bottom of the sea, it is hardly possible to doubt, while admitting that it receives modification from other, and perhaps more general, causes. The after progress of this mighty stream, and of its branches if it does divide, remains yet to be traced and and so also its heading in the Gulf of Mexico.

I forbear to mingle doubtful speculation upon causes, with the inductions in regard to temperatures, which it has been the object of these observations to supply and of this lecture to bring to your notice.

Art. XXIX.—*On Fermented and Aërated Bread, and their Comparative Dietetic Value;* by J. Dauglish, M. D.*

[Extracted from the London Medical Times and Gazette, vol. i, p. 468, 1860.]

Since the new process of preparing bread has been introduced,—a process which effects the raising of bread wholly by mechanical means, imparting to it the most perfect vesicular structure, while it leaves the constituents of the flour wholly unchan-

* As most of our readers are doubtless aware, Dr. Dauglish is the author of a new system of bread making that has excited considerable interest among chemists during the last twelvemonth.

An extended description of this method was read at the Aberdeen meeting of the British Association in Sept., 1859, by Dr. Odling, from whose paper we take the following extracts.

"It is well known that the vesicular character of ordinary bread results from the development of carbonic acid gas uniformly throughout a mass of fermenting dough, whereby a loose spongy texture is imparted to what would otherwise be a dense sodden lump of baked flour and water. In fermented bread the carbonic gas thus generated within the substance of the dough is a product of the transformation or degradation of one of the constituents of the flour, viz., of the starch or sugar.

"In the plan of Dr. Dauglish the carbonic acid is produced independently and superadded to the flour which consequently need not undergo any degradation whatever. Water charged with carbonic acid (common "soda water") is mixed under pressure with the flour and the resulting dough, which becomes vesicular when the pressure is removed, is divided into loaves and baked in the ordinary way.

"The advantages claimed for the new process, are, 1st. Its cleanliness. Instead of the dough being mixed with naked arms or feet, the bread, from the wetting of the flour to the completion of the baking is not, and scarcely can be touched by any one. 2d. Its rapidity. An hour and a half serves for the entire conversion of a sack of flour into baked loaves, whereas in the ordinary process, four or five hours are occupied in the formation of the sponge, and a further time for the kneading, raising, and baking of the dough. 3d. Its preventing deterioration of the flour. In making fermented bread from certain varieties of flour, not in themselves unwholsome, the prolonged action of warmth and moisture induces a change of the starchy matter of the flour into dextrine, whereby the bread becomes sodden and dark colored. This change is usually prevented by the addition of alum, which is indeed

ged and uncontaminated,—there has not been wanting those who doubt whether the process of fermentation, by which bread has been hitherto prepared, is not really beneficial in other respects than that of imparting the vesicular structure to it; whether, in fact, the changes which the constituents of the flour —especially the starch—undergo, are not essential to healthy digestion in the stomach.

Although I believe there are few members of the Medical profession who will be prepared to maintain that fermentation is beneficial, still, as some do hold such an opinion, and have asserted likewise that starch which has not undergone the fermentive process is wholly unfit for human food, I am desirous of stating what I believe are good reasons for rejecting the process of fermentation for the new one which I have introduced.

In order to dispose of the assertion that starch requires to be prepared by the fermentive changes to render it fit for human food, it is but necessary to remark, that the proportion which the inhabitants of the earth, who thus prepare their starchy food, bear to those who do not, is quite insignificant. Indeed, it would appear that the practice of fermenting the flour or meal of the cereal grains is followed chiefly by those nations who use a mixed animal and vegetable diet, while those who are fed wholly on the products of the vegetable kingdom reject the process of fermentation entirely. Thus, the millions of India and China, who feed chiefly on rice, take it for the most part simply boiled; and that large portion of the human race who feed on maize, prepare

an almost necessary ingredient in the manufacture of bread from glucogenic flour. But in operating by the new process, there is no time for glucogenic change to take place, and consequently no advantage in the use of alum, with any description of flour. 4th. Its certainty and uniformity. Owing to differences in the character and rapidity of the fermentation, dependent on variations of temperature, quality of the yeast, &c., the manufacture of fermented bread frequently presents certain vagaries and irregularities from which the new process is entirely free. 5th. The character of the bread. Chemical analysis shows that the flour has undergone less deterioration in bread made by the new, than in that made by the fermented process. In other words, the percentage of extractive matters is smaller. The new bread has been tried dietetically at Guy's Hospital and by many London physicians and has been highly approved of. It is well known that for some years past, the use of fermented bread in dyspeptic cases, has been objected to by members of the medical profession, the debris of the yeast being considered unwholesome and liable to induce acidity. 6th. Its economy. The cost of carbonic acid is alleged to be less than the cost of yeast. Moreover, in making fermented bread there is a small but necessary waste of the saccharine constituents, which is avoided by the new process. 7th. The saving of labor and health. It substitutes machine labor for manual labor of a very exhausting kind. The sanitary condition of journeymen bakers was investigated some time ago by Dr. Guy, and found to be most lamentable, from their constant night work and from the fatiguing and unwholesome character of their labor, particularly the kneading In a politico-economical point of view, the process is important as removing bread-making from a domestic manual work, to a manufacturing, machine work."

From the character of the apparatus, the process can only be used profitably on a large scale, and not in small bakeries. F. H. S.

it in many ways, but they never ferment it. The same is true with the potato-eater of Ireland, and the oatmeal-eater of Scotland. Nor do we find that even wheat is always subjected to fermentation; but the peculiar physical properties of this grain appear to have tasked man's ingenuity more than any other, to devise methods of preparing from it food which shall be both palatable and digestible. In the less civilized states, a favorite mode of dressing wheat grain has been, by first roasting and then grinding it. On the borders of the Mediterranean it is prepared in the form of maccaroni and vermicelli, while in the East it is made into hard thin cakes for the more delicate, and for the hard working and robust into thicker and more dense masses of baked flour and water. Even in our own nurseries wheaten flour is baked before it is prepared with milk for infants' food. The necessity of subjecting wheaten grain to these manipulations arises from its richness in gluten, and from the peculiar properties of that gluten. If a few wheaten grains are taken whole and thoroughly masticated, the starchy portion will be easily separated, mixed with the saliva and swallowed, whilst nearly the whole of the gluten will remain in the mouth in the form of a tough tenacious pellet, on which scarcely any impression can be made. A similar state of things will follow the mastication of flour. In this condition, the gluten is extremely indigestible, since it cannot be penetrated by the digestive solvents, and they can only act upon its small external surface; hence the necessity to prepare food from wheat in such a manner as shall counteract this tendency to cohere and form tenacious masses. This is the object of baking the grain and flour as before mentioned, of making it into maccaroni, and of raising it into soft spongy bread; by which latter means the gluten assumes a form somewhat analogous to the texture of the lungs, so that an enormous surface is secured for the action of the digestive juices; and this I believe is the sole object to be sought in the preparation of bread from wheaten flour.

Wheat is said to be the type of adult human food. It supplies, in just proportions, every element essential to the perfect nutrition of the human organism. And yet in practice we find that the food which we prepare from it, and furnish to the inhabitants of our large towns and cities, is quite incapable alone of sustaining the health and strength of any individual. This is the more remarkable, since in Scotland we find that the food prepared from the oat, a grain possessing the same elements of nutrition as wheat, though in a coarser form,—furnishes almost the exclusive diet of a very large number of the hardiest and finest portion of the population.

In the large towns of France wheaten bread certainly forms a very large proportion of the diet of the laboring classes, but not

so large as oatmeal does in Scotland. And yet it has been remarked by contractors for public works on the Continent, that the chief reason why the Englishman is capable of accomplishing double the work of a Frenchman is, that the one consumes a very large proportion of meat, while the diet of the other is chiefly bread. In Scotland, however, the laboring man is capable of sustaining immense fatigue upon the nourishment afforded by oatmeal porridge.

The deficiency in wheaten bread in affording the nourishment due to the constituents of the grain, is to be attributed solely to the mode of preparing the flour, and the process followed for making that flour into porous bread.

The great object sought after both by the miller and the baker, is the production of a white and light loaf. Experience has taught the miller that the flour which makes the whitest loaf is obtained from the centre of the grain; but that the flour which is the most economical, and contains the largest portion of sound gluten, is that which is obtained from the external portion of the grain. But while he endeavors to secure both these portions for his flour, he takes the greatest care to avoid as much as possible, by fine dressing, etc., the mixture with them of any part of the true external coat which forms the bran, knowing that it will cause a most serious deficiency in the color of the bread after fermentation.

It is generally supposed that the dark color of brown bread —that is of bread made from the whole wheaten meal—is attributable to the colored particles of the husk or outer covering of the grain. But such is not really the case. The colored particles of the bran are of themselves only capable of imparting a somewhat orange color to bread, which is shown to be the fact when whole wheaten meal is made into bread by a process where no fermentation or any chemical changes whatever are allowed to take place. Some few years since, a process was invented in America for removing the outer seed coat of the wheat grain without injuring the grain itself, by which it was proposed to save that highly nutritious portion which is torn away, adhering to the bran in the ordinary process of grinding, and lost to human consumption. The invention was brought under the notice of the French Emperor, who caused some experiments to be made in one of the government bakeries to test its value. The experiments were perfectly satisfactory so far as the making of an extra quantity of white flour was concerned, but when this flour was subjected to the ordinary process of fermentation and made into bread, much to the astonishment of the parties conducting the experiments, and of the inventor himself, the bread was brown instead of white. The consequence, of course, has been that the invention has never been brought into practical operation.

It has been estimated that as much as ten or twelve per cent of nutritious matter is separated adhering to the bran, which is torn away in the process of grinding, and until very lately this matter has been considered by chemists to be gluten. It has, however, been shown by M. Mège Mouriès to be chiefly a vegetable ferment, or metamorphic nitrogenous body, which he has named Cerealin, and another body, vegetable Caseine.

Cerealin is soluble in water, and insoluble in alcohol. It may be obtained by washing bran, as procured from the miller, with cold water, in which it dissolves, and it may be precipitated from the aqueous solution by means of alcohol; but, like pepsin, when thus precipitated it loses its activity as a solvent or ferment.

In its native state or in aqueous solution, it acts as the most energetic ferment on starch, dextrine, and glucose, producing the lactic and even the butyric changes, but not the alcoholic.

It acts remarkably on gluten, especially when in presence of starch, dextrine or glucose. The gluten is slightly decomposed at first, giving ammonia, a brown matter, and another production which causes the lactic acid change to take place in the starch and glucose. The lactic acid thus produced immediately combines its activity with that of the cerealin and the gluten is rapidly reduced to solution.

The activity of the cerealin is destroyed at a temperature of 140° Fah., according to M. Mouriès, but my own experiments show that it is simply suspended even by the heat required to cook bread thoroughly; thus bread made without fermentation, of whole wheaten meal, or of flour in which there is a large proportion of cerealin, will, if kept at a temperature of about 75° to 85° Fah., pass rapidly into a state of solution, if the smallest exciting cause be present, such as ptyaline or pepsin, or even that small amount of organic matter which is found in impure water—while the same material, when it has been subjected to the alcoholic fermentation, will not be affected in a like manner.

The activity of cerealin is very easily destroyed by most acids, also by the presence of alum; and while it is the most active agent known in producing the earlier changes in the constituents of the flour, it cannot produce the alcoholic, but as soon as the alcoholic is superinduced the cerealin becomes neutralized and ceases to act any longer as a solvent. M. Mouriès, taking advantage of this effect of alcoholic fermentation, has adopted a process by which he is enabled to separate from the bran all the cerealin and caseine which are attached to it. He subjects the bran to active alcoholic fermentation, which neutralizes the activity of the cerealin, and at the same time separates the nutritious matter; and then having strained this through a fine seive, he adds it to the white flour in the preparation of white bread, by which an economy of ten per cent is effected, and the color of the bread is not injured.

The peculiar action of cerealin as a special digestive solvent of the constituents of the flour—gluten and starch—has been practically tested by Mr. Stephen Darby, of Leadenhall-street, in a series of careful experiments. He found that when two grains of dry cerealin were added to 500 grains of white flour, and the whole digested in half-an-ounce of water at a temperature of 90° for several hours, ten per cent more of the gluten, and about five per cent more of the starch, were dissolved than when the same quantity of flour was subjected to digestion without the addition of cerealin, but in which of course there was a small amount of cerealin that is present in all flours. The action of cerealin upon the gluten of wheat is precisely similar to that of pepsin on the fibrine of meat. Pepsin, acting alone on fibrine dissolves it, but very slowly, but if lactic acid be added solution takes place very rapidly. In like manner the starch present with the gluten of wheat is acted upon by the cerealin, and produces the necessary lactic acid to assist in the solution of the gluten by cerealin.

With the knowledge thus obtained of the properties of this substance cerealin, it is not difficult to understand why the administration of bran-tea with the food of badly-nourished children, produces the remarkable results attributed to it by men both experienced and eminent in the Medical profession; and why, also, bread made from whole wheaten meal, which contains all the cerealin of the grain, should prove so beneficial in some forms of mal-assimilation, notwithstanding the presence of the peculiarly indigestible and irritating substance forming the outer covering of the grain.

It will be seen that in all the methods of bread-making hitherto adopted, the peculiar solvent properties of this body, cerealin, have been sought to be neutralized simply because it destroys the white color of the bread during the early stages of panary fermentation. It is by thus destroying the activity of the special digestive ferment which Nature has supplied for the due assimilation by the economy of the constituents of the wheaten grain, that wheaten bread is rendered incapable of affording that sustenance to the laboring man which the Scotchman obtains from his oatmeal porridge. Although the new bread has been as yet but little more than experimentally introduced to public consumption, I have already received from members of my own profession, who have recommended it in their practice, as well as from non-professional persons, accounts of the really astonishing results that have followed its use in cases of deranged digestion and assimilation. Private gentleman have sought interviews wi h me to record the history of their recovery to health, after years of suffering and misery, by the simple use of the bread as a diet. Children that have been liable to convulsive attacks from

an irritable condition of the alimentary canal and nervous system, have been perfectly free from them immediately the new bread was substituted for fermented bread. And cases are now numerous that have been communicated to me by medical men of position, in which certain distressing forms of dyspepsia, which had remained intractable under every kind of treatment, have yielded as if by magic almost immediately after adopting the use of the aërated bread.

The delicate flavor of the new bread renders it peculiarly grateful to the stomachs of invalids and children, as well as of those whose tastes have not become vitiated by the habitual use of baker's bread, which is slightly sour, and tastes of yeast. The new bread was supplied to two wards in Guy's Hospital in place of the ordinary bread (which is of a very fine quality, made on the premises,) for two months, and in no case were there any pieces left in the wards unconsumed, while of the fermented bread large quantities of scraps were collected daily, for the consumption of which the appetites of the patients have been deficient.

That persons who have been long used to the strong yeasty-flavored bakers' bread should consider the new bread tasteless at first is not to be wondered at, since the delicate sense of taste is of all other senses the most easily lost by rough usage. Hence the argument put forth in defence of adulteration by some London tradesmen, especially the beer sellers, that the public will not buy the pure article, as it is wanting in the flavor to which they have been accustomed; and hence, also, the dislike of the Viennese of the fresh oysters supplied to them when the railway was completed, as they deemed them insipid, after the habitual use of oysters slightly decomposed, with which they had been supplied when it required a lengthened period to transport them from the sea.

I am disposed to attribute the beneficial effects of the new bread to two causes. The one to the *absence* of the prejudicial matters imparted to ordinary bread by the process of fermentation, and the other to the *presence* in the bread, unchanged, of that most essential agent of digestion and assimilation, cerealin.

I believe the prejudicial matters imparted to bread by fermentation to be chiefly two—acetic acid and the yeast-plant. The first is produced in large quantities, especially in hot weather, by the oxydation, by atmospheric contact, of the alcohol produced. The second is added when the baker forms his sponge, and is also rapidly propagated during the alcoholic fermentation, and cannot of course be afterwards separated from the other materials in the manner that the yeast and the other *débris* of fermentation separate themselves from wine and beer by precipitation in the process of fining. Nor is the life of the yeast-plant gene-

rally destroyed in baking, because it requires to be retained at the boiling point for some time before it is thoroughly destroyed; and bread is generally withdrawn from the oven, for economical reasons, even before the centre of the loaf has reached the temperature of 212°. It is not difficult to understand how the most painful and distressing symptoms and derangements may follow the use of bread in which the yeast-plant is not thoroughly destroyed previous to ingestion, and in those cases of impaired function in which the peculiar antiseptic influence of the stomachal secretions is deficient, and is incapable of preventing the development of the yeast-plant in the stomach, and the setting up of the alcoholic fermentation to derange the whole process of digestion and assimilation.

The presence of cerealin in bread is as beneficial as that of acetic acid and the yeast-plant is prejudicial. Digestion, or the reduction of food is evidently essentially dependent on the action of a class of substances which chemists, for want of a better term, have called ferments—to these substances belong pepsin, ptyaline, emulsin, diastase and cerealin; these are evidently types of a very numerous class, which act by producing those molecular changes in organic substances in which digestion consists; and since the purpose of digestion or solution is to prepare from heterogeneous substances taken as food a chyle, which shall not only when absorbed present all the elements of healthy blood, but shall previous to absorption, possess the properties which will constitute it the proper stimulus to the functional activity of the lacteals, it would appear to be necessary that each distinct substance taken as food should be furnished, not with its simple chemical solvent, but with that peculiar form of solvent or ferment which alone can carry it through those molecular changes which shall terminate in the production of healthy chyle. Hence we should infer that a substance was digestible or indigestible just in proportion to the provision that is made for its reduction to the standard of healthy chyle, and that substances which have hitherto been incapable of affording any nutrition whatever, may at some future day be rendered highly nutritious, simply by adding to them suitable ferments, artificially obtained or otherwise, that shall secure their passage through the proper molecular changes. Indeed, I think this subject opens up to us that very wide field of inquiry, as to whether the cause and prevention of disease, and the beneficial administration of remedies may not, for the most part, if not entirely, be dependent on the action of substances analogous to such bodies as ptyaline, pepsin, cerealin, etc., acting in concord with, or retarding and opposing the vital functions of tissues; and that by more profound inquiry in this field of research, the physiologist and the pathologist may not at a future day lay the foundation of true scientific Medicine.

Tunbridge Wells.

ART. XXX.—*Additional Note on the Potsdam Fossils;* by E. BILLINGS.

SINCE my note to Mr. Bradley's paper was written, he has collected quite a number of new specimens of *C. minutus* at the same locality. At his request I have examined them and find that they exhibit several of the parts not preserved in those upon which the original description was founded.

Fig. 4, (nat. size).

Fig. 4.— *a*, A detached cheek showing the small spine of the posterior angle.
b c, Two specimens of the glabella, showing the spine on the neck segment.

1. The posterior angles of the head are produced into short spines, as we supposed, but these spines, instead of being elongate-triangular are sub-cylindrical or needle-shaped and projected outwards at an angle of 45° or thereabouts, to the longitudinal axis of the body. The cheek does not appear to be striated but rather smooth. These two characters furnish additional grounds for separating the species from *C. antiquatus* (Salter), which has the cheeks striated and the posterior angles of the head only slightly produced into short broadly triangular terminations.

2. The neck segment bears a short broad-based spine. The first specimens collected do not exhibit this, but on reëxamining them I think I can see traces of it. Some of the specimens of *C. coronatus* (Barrande) lately collected in the Primordial Zone of Spain have a spine on the neck segment of the same form as that of *C. minutus*, while others (according to the figures) have not; and it may be that individuals of our species will yet be discovered in which the absence of the spine can be clearly established. This remark is made here because on comparing the figures of the Bohemian and Spanish specimens of *C. coronatus* it would appear that the presence or absence of a spine on the neck segment is not always of specific importance and should some of those from Keeseville turn out to have only a plain neck segment we would not perhaps on that ground alone be authorized to constitute two species.*

* Compare the article, *Sur l'existence de la faune primordiale dans la chaine cantabrique*, par M. Casiano de Prado; suivie de la *Description des fossiles*, par MM. de Verneuil et Barrande. Bulletin Geol. Soc. France, 2e Series, vol. xvii, p. 516, (1860). And also Barrande's *Système Silurien*, plate 13.

3. Mr. Bradley's new specimens also show that there are three pairs of glabellar furrows, the anterior being represented by two small indentations just in advance of the points where the ocular ridges reach the glabella; and further that the course of the facial suture is the same as it is in *C. striatus*, (Emerich). The pygidium is more obtusely rounded than is represented in our Figure 2.

As to the correctness of the generic reference of this species it may be remarked that Barrande is of opinion that no less than eleven of those which Angelin has figured under the genera *Solenopleura*, *Eryx*, *Conocoryphe* and *Harpides* should be placed in *Conocephalites*. In this view of Barrande's, Angelin has concurred.* The genus has thus been greatly extended and judging from the form of the head (and more particularly of the glabella) of Angelin's species *C. brachymetopus*, *C. homelotopus* and *C. canaliculatus* I think we are perfectly justified in referring this species to *Conocephalites*. The genus is most closely allied to *Calymene*, having the same number of segments in the thorax —the same number and arrangement of pieces in the head and the same general form and lobation of the glabella, the differences between the genera consisting principally in certain characters of the pleuræ and hypostoma† to which may be added the ocular ridge which although not a constant character in *Conocephalites* may be regarded as of some generic value as it does not occur at all in *Calymene*. I would also state that since examining Mr. Bradley's recent collection, I have been strongly impressed by the resemblance between the form of the cheek and small needle-shaped posterior spines of *C. minutus* and the same parts of the head of the Quebec species which I have called *Menocephalus globosus*, and it appears to me that *Menocephalus* must be regarded as another closely allied genus. If we except those two genera, *Calymene* and *Menocephalus*, there is no other but *Conocephalites* to which our new trilobite bears any near affinity.

* See Barrande's "*Parallèle entre les dépôts Siluriens de Bohême et de Scandinavie*, p. 19; and compare the tables on p. 17 and 35 of the same work. See also Angelin's *Palæontologia Scandinavica*.

† See Barrande, "*Système Silurien du centre de la Bohême*," p. 417–419.

Montreal, 20th Sept., 1860.

ART. XXXI.—*The Great Auroral Exhibition of Aug. 28th to Sept. 4th*, 1859.—6TH ARTICLE; by Prof. ELIAS LOOMIS.

SINCE our last Auroral article was prepared for the press, the following letter has been received from the Secretary of the Smithsonian Institution.

Washington, June 6th, 1860.

Dear Sir:—Some time since, you wrote us in regard to the aurora of September, 1859, and I now write to inform you that we have a very large collection of materials in regard to this interesting meteor which in justice to the writers ought to be published. It is, however, a pity that the data for scientific deductions in regard to this interesting phenomenon should be scattered, and we will therefore present the whole to Silliman's Journal, provided the Editors will publish it. Will you take charge of it, and prepare it for the press?

JOSEPH HENRY, *Secretary S. I.*

The editors of this Journal have accepted the liberal proposition of Prof. Henry, so far as to publish whatever might be supposed to be of importance in an investigation of the theory of the Aurora. A considerable portion of the materials collected by the Smithsonian Institution have already appeared in former numbers of this Journal, and many of the reports are from neighboring stations where the Auroral appearances are almost identically the same. From the entire mass of materials we have aimed to select those Reports only which were the most complete and elaborate, and which were so distributed in geographical position as to afford a correct idea of the appearances throughout the entire area of the United States.

OBSERVATIONS OF THE AURORA OF AUGUST 28TH, 1859.

Selected from the Smithsonian Papers.

1. *Observations at Burlington, Minnesota*, (lat. 47° 1′, long. 92° 30′), *by* A. A. HIBBARD.

The aurora of Aug. 28th, commenced at 8 P. M., and increased very rapidly until 8½ P. M., when it came to a centre directly over our heads. It went about three-fourths the circumference of the horizon at the base, and completely round at the top, and down about one-third on the south side. Stars very bright and light enough to read very fine print. At 9 P. M. it had nearly disappeared over head; and but few beams to be seen in any part of the horizon, although new beams were forming in the north. At 9½ P. M. the beams were very light, and somewhat scattered. At 10 P. M. it had entirely disappeared.

2. *Observations at Marquette, Michigan*, (lat. 46° 32′, long. 87° 41′), *by* Dr. G. H. Blaker.

Aug. 28th, at 8 P. M., a bright crown overhead, with beams or streamers extending to every point of the compass, but soon lost in a white haze. In the course of an hour these streamers extended to the horizon in every direction, with bright streams of white light shooting up towards the crown, all of which became perfectly red, or of a bright crimson color over head. This continued to increase in brightness until after midnight, with floods of white light at the horizon, all passing into crimson fleecy vapor in the zenith.

3. *Observations at Winona, Minnesota*, (lat. 44° 3′, long. 91° 36′), *by* T. F. Thickstun.

Aug. 28th, an auroral bank and a few pencilled streamers had formed at 9½ P. M. At midnight the streamers and corona filled the whole heavens except the N. E. portion. During the whole night the light was equal to that of a half moon.

4. *Observations at Green Bay, Wisconsin*, (lat. 44° 30′, long. 87° 56′), *by* D. Underwood.

Aug. 28th, about 7½ P. M., the aurora was visible in the northern part of the heavens, but did not attract particular notice until about 9 P. M. Soon after eight the sky began to redden, and became nearly of a blood-red color. Soon the streaks were observed shooting upward from all points of the horizon, and concentrating in a large luminous mass in mid-heavens. The greatest intensity of color was at the zenith. Rays were constantly shooting up from all points of the horizon and the colors constantly changing. The rays emitted an intense red light for about half an hour, when they began slowly to fade away in the north and south, but in the east and west they continued to glow until 10 P. M., when they began to fade away. Flashes of white light appeared among them, commencing from the horizon and moving upwards, following each other in rapid succession like the waves of an immense sea of light. They grew brighter as the red color disappeared, and when this was wholly gone they also gradually faded away.

5. *Observations at Milwaukee, Wisconsin*, (lat. 43° 3′, long. 87° 57′), *by* Prof. E. P. Larkin.

Aug. 28th, at 8 P. M., an aurora commenced. About 8½ P. M. an arch formed from S.W. by the north to the S.E., with dark broken clouds below. The streamers now commenced, principally in the N.W. and N.E., and were surprisingly beautiful, of crimson, purple, peach and orange; the crimson predominating. At $8^h\,45^m$ a perfect corona formed a few degrees south of the zenith.

At 9 P. M. the aurora began to fade, and at ten had nearly disappeared. At 10½ P. M. the north gave indications of another aurora which occurred about 12 o'clock, nearly equal in splendor to the first, and still another occurred about 3 A. M. There were also auroras late in the night of the 30th and also of the 31st.

6. *Observations at Burlington, Wisconsin*, (lat. 42° 39′, long. 87° 44′), *by* D. MATHEWS.

Aug. 28th, at 8 P. M., the appearance was that of a large luminous ring surrounding the zenith; but this form was very transient, the light becoming concentrated in the west. Between 8 and 9 P. M. there were two arches formed in the north, the first almost 30° in altitude, and the second about 40°. From the outer edge of the larger arch darted a succession of streamers or rays of light. At $8^h\ 15^m$ a perfect flood of light came up in the east, not in streams, but like the dawn of day, just before sunrise. This appearance lasted about half an hour. At 9 P. M. streams of light radiated in every direction from a point about ten degrees south of the zenith, covering the whole heavens except a space in the south. One broad belt of red light extended from near the zenith to the horizon at a point a little north of west.

7. *Observations at Dubuque, Iowa*, (lat. 42° 30′, long. 90° 52′), *by* ASA HORR, M.D.

Aug. 28th, the aurora began with floating irregular masses of auroral clouds in the north, which soon spread over the sky, terminating in a broad zone of light spanning the heavens from E. to W. and reaching to 20° south of the zenith. At 8 P. M. many of the luminous clouds became distinctly crimson, with the deepest hue near the horizon. At $8^h\ 15^m$ a distinct arch formed in the north crowned with tall flickering white streamers. The crimson clouds now dissolved into paler streamers; at $8^h\ 35^m$ the streamers subsided; and at $8^h\ 40^m$ the red clouds near the horizon and the diffuse light in the north appeared again. From this time till 9 P. M. a crimson shade was spread over the whole of the broad belt, with varying hue and brightness. The arch in the north formed again with whitish streamers which remained moderately bright until 11 P. M.

8. *Observations at Waltham, Massachusetts*, (lat. 42° 24′, long. 71° 14′), *by* Rev. THOMAS HILL.

Aug. 28th, at 7½ P. M., there were visible some splendid masses of rose-colored light in the east and west near the horizon; that in the west being nearly obscured by twilight. At $7^h\ 45^m$ a well defined arch passed south of the zenith, and all the sky north of it was filled with light, radiating toward the pole of the

dipping needle. I watched the aurora from 9 to 10½ P. M., and at 3 A. M. got up again to look. It was then very brilliant and rosy all along the southern horizon.

9. *Observations at Monroe, Michigan*, (lat. 41° 56′, long. 83° 22′), *by* Miss HELEN J. WHELPLEY.

Aug. 28th, about 8½ P. M., there was a broad line of intensely yellow light extending from east to west. In a few moments the whole sky to within 20° of the south, seemed to be permeated with a clear whitish light; yellowish rays constantly shooting up from the east, north and west horizon to the zenith. At the same time appeared a bright rose colored mass in the east, which gradually enlarged until it covered nearly three-fourths of the heavens, and about 9 P. M. the rays met and formed a perfect corona a little south of the zenith.

10. *Observations at Willow Creek, Illinois*, (lat. 41° 45′, long. 88° 56′), *by* E. E. BACON.

Aug. 28th—aurora first seen at 8 P. M., corona and beams at $8^h\ 40^m$, arch $8^h\ 45^m$. Beams of red very brilliant in the east and west, and at the corona from $8^h\ 35^m$ to $8^h\ 55^m$. At 9^h the beams and corona had disappeared, and a broad red belt extended across the heavens, passing over to the south. Two distinct arches were formed in the north. At $9^h\ 15^m$ bright beams in the southeast, the red belt disappearing in the east. At $9^h\ 25^m$ redness nearly gone. At $9^h\ 28^m$ arches broken. At $9^h\ 35^m$ brilliant spot in N.E. At $9^h\ 40^m$ arch reformed, but not so brilliant. At $12^h\ 30^m$ beams with far greater grandeur than at $8^h\ 40^m$. Beams streamed from all round the horizon to the zenith. In the southern half of the sky, the beams flashed like the blaze of a great fire. At $12^h\ 45^m$ a bright belt from E. to W., in the south, with a dark belt something like a cloud under it. At $1^h\ 12^m$ bright belt in the south gone. Aurora lasted till daylight.

11. *Observations at Sandwich, Illinois*, (lat. 41° 31′, long. 88° 30′), *by* Dr. N. E. BALLOU.

Aug. 28th, at 7½ P. M., there was a bright luminous band, a degree in width, spanning the heavens. Soon it became tortuous; and in the zenith it pointed southward half way to the horizon. At 8 P. M. red gleams shot up in the N.W. directly to the zenith. At 8½ P. M. the same appearance sprung up in the N.E. At 9 P. M. the entire northern half of the sky was brilliantly red, with gleams which soon culminated in a corona. At 9½ P. M. the whole was tinged with red, alternating with beams of light. At 10 P. M. the red tinge floated away to the south. At midnight it presented much the same appearance as before.

12. *Observations at Sag Harbor, New York*, (lat. 41° 0′, long. 72° 20′), *from the Sag Harbor Express.*

Aug. 28th—between 8 and 9 o'clock rays of clear, white light arose from every part of the horizon, and soon met in a common focus at a point about 15° S.E. of the zenith, amid the four stars forming the trapezium of the Dolphin. At 10 P. M. a more dense light appeared at two points on the horizon a little north of east and west. These were at first of a bright yellow light; but at 10½ P. M. that in the east assumed a dark crimson hue, and the light in the west was tinged with a paler red. At this time began the waves of undulating light, their motions being upward and across the radial columns in a direction from east to west.

At midnight the brightness of the columns increased, the undulations increased, especially in the south, and their motions became exceedingly rapid. The usual dark bank now appeared upon the horizon in the south, well defined, but occasionally broken by minor columns of light. The whole heavens continued thus glowing until the aurora was eclipsed by the light of day.

13. *Observations at Kanosha, Nebraska*, (lat. 40° 51′, long. 95° 44′), by BELA WHITE.

There was a very brilliant light of a pink color from about 1 A. M. Aug. 29th until daylight in the northern half of the hemisphere, shooting upwards to the zenith, and passing off to the south. It was so light as to enable a person to read coarse print.

14. *Observations at Great Salt Lake City, Utah*, (lat. 40° 45′, long. 111° 26′), *by* W. W. PHELPS.

Aug. 28th between 9 and 10 P. M. a palish light wavered up about 30° towards the zenith; thence it spread east and west with increasing grandeur, till about 11 P. M. when the perpendicular streams beautified a large portion of the northern hemisphere. The light about 20° above the horizon, decreased upward and downward, so that at nearly midway to the zenith, the light changed into a fine yellow green, which was joined by a rich livery of crimson, spanning the whole heavens from east to west, as a belt several degrees wide. This magnificent phenomenon continued in varying hues, until about 1 A. M.

15. *Observations at New York City*, (lat. 40° 43′, long. 74° 5′), *by* Prof. O. W. MORRIS.

Aug. 28, 8 P. M. there was a bright band above the horizon, which spread upwards with rays. At $9^h\ 10^m$ the light spread over the heavens, occupying the zenith and either side with white, and interspersed with pink colored portions. At $9^h\ 20^m$ it formed an arch in the south with a dark segment below, while the northern portion of the sky was perfectly clear. At $9^h\ 25^m$

the beams shot up from all sides to the zenith, forming a beautiful corona which lasted 5 or 8 minutes, sometimes putting on the appearance of conflicting waves. Nearly the whole sky was of a pink, and some portions of a dark red color. It faded gradually away, first disappearing in the south, and at 10 P. M. only a bright band across the northern portion without a dark segment. About $10^h\ 30^m$ occasional rays shot up to the zenith. At 11^h it was very light, so that objects could be seen at a distance. The aurora continued with varied colors and brightness until the dawn of the 29th.

16. *Observations at Pekin, Illinois*, (lat. 40° 36′, long. 89° 45′), *by* J. H. Riblet.

Aug. 28, $8^h\ 20^m$ P. M. a white band running from N. W. to E. with two columns shooting up, one by the north star the other through Ursa Major. $8^h\ 30^m$ it is passing westward and a high column is passing about 5° east of the north star, and about 10° above it. At $8^h\ 40^m$ two columns passing nearly to zenith on the east side of north star. At $8^h\ 46^m$ the column by the north star increased in width, the top bent over forming a semicircle to west. Color white in north, changing to a rose at its upper edge, and a red in the east. At $8^h\ 55^m$ arches forming; the lowest about 10° above the horizon, and of a pale color. The second about 30° above the horizon, and of a pale orange color. Streamers running from the lower arch through it and about 30° above it. The color was most intense in the east. At $8^h\ 57^m$ both arches better defined. The streamers passing from the lower through the upper to a point about 10° west of the zenith. At 9 P. M. less brilliant and ceased observing.

17. *Observations at Urbana, Ohio*, (lat. 40° 6′, long. 83° 43′), *by* Prof. M. G. Williams.

Aug. 28th, at 9 P. M. columns of white and yellowish light shot from all points of the arch which extended from N. 80° E. to N. 75° W. Many of the corruscations passed beyond the zenith; in the east the light was pink and deep crimson forming a mass about 30° broad and 60° high reaching down to the horizon. The color was sometimes almost blood red. At $9^h\ 10^m$ a similar mass formed in the N.W. At $9^h\ 15^m$ a remarkably beautiful column shot up at N. 50° W. having a breadth of 10° and reaching to the zenith. The colors were white, yellowish, pink and crimson. About $9^h\ 20^m$ an arch was formed in the south, having an altitude of 40° at the centre. A few minutes later, the crimson light extended down from the zenith, quite to this arch, so that most of the sky was covered with colored light. At $9^h\ 50^m$, a beam 2° broad, shot up from S. 80° W. passing 20° or 30° beyond the zenith. In a few minutes the beam seemed to be broken up into fragments of 5° or 6° in length, and presently

vanished. At 10 P. M. the brightness was much diminished; at $10^h\ 15^m$ revived; the northern arch very brilliant and slightly tinged with crimson. At $10^h\ 30^m$ the arch extended from E. to N. 85° W. At midnight the exhibition was still fine. From $2\frac{1}{2}$ to 3 A. M coruscations of white light shot up all along the horizon from E. to S. 15° W. The aurora continued to decline, till the dawn of day.

18. *Observations at Henry Co., Indiana*, (lat. 40°, long. 85° 15′), *by* WILLIAM DAWSON.

Aug. 28th, about 9 P. M. a red cloud covered a large portion of the eastern sky with a similar one in the N.W. and several large luminous beams extended from the north point to the zenith. Soon the red disappeared, and the bright streaks grew much shorter, leaving a bright cloud brilliantly fringed with white, near the northern horizon. After some minutes, several small bodies, like long white clouds, started from about 25° S.E. of the zenith, and moved slowly towards the west, disappearing about the same distance nearly S.W. of the zenith. About midnight, a dark cloud decked with immense streamers of white, glaring light, rested on the northern horizon, when suddenly it burst forth into streaming corruscations of red, purple and white lights, shooting to a point 15° or 20° south of the zenith, where these flashing lights presented the appearance of a cloud, tinted with vermillion and purple. At $12\frac{1}{2}$ A. M. fully two-thirds of the heavens were wrapt in flashing torrents of streamers directed towards this point. This tremulous illumination lasted about an hour, when it partly vanished; but soon the sky was again covered with darting streamers nearly as before, and the light seemed more vivid than at $12\frac{1}{2}$ A. M. At 2 A. M. the light had in a great measure passed away.

19. *Observations at Gettysburg, Pennsylvania*, (lat. 39° 49′, long. 77° 15′), *by* Rev. M. JACOBS.

Aug. 28th, the aurora was visible in the evening twilight especially to N. and N.E. At 9 P. M. the whole sky as far south as within 30° of the southern horizon was covered with alternate bands of luminous matter like cirrus cloud. At $9^h\ 25^m$ the luminous band within about 20° of the northern horizon began to shoot up streamers, and soon became a mass of streamers which filled the whole northern sky, darting up to a point about 2° east of Aquila, where they crossed, some radiating thence southward. The streams were visibly wafted round on the east and west, to the S.E., S.W. and even south. The streamers were mostly of orange, white below and crimson red above. At 10 P. M. the sky was mostly clear; the bank of vapor, dark below but luminous above, with a few streamers occupied the northern horizon, rising to the height of 20° or 25°. The light was equal to that of the moon at quadrature.

20. *Observations at College Hill, Ohio.* (lat. 39° 19′, long. 84° 26′), *by* Prof. J. H. WILSON.

Aug. 28th, the aurora commenced at 8 P. M. and continued with increased splendor till 1 A. M. The corona formed about 10 P. M. with arch and beams. At 1 A. M. the coruscations darted from the horizon upward to the zenith and about 20° beyond. The light was equal to the clearest full moon.

21. *Observations at Wyandott City, Kansas,* (lat. 39° 7′, long. 94° 44′), *by* JOHN H. MILLAR.

Aug. 28th, at 11½ P. M. a diffused light was observed in the N.N.E. gradually increasing until at 1 A. M. the whole northern sky from N.W. by W. to S.E. by E. was covered with rays and streamers of moderate brightness, shooting up to within 30° of the zenith, and changing rapidly, from a uniform white to a tinge of purple. The aurora passed off about 1½ A. M.

22. *Observations at St. Louis, Missouri,* (lat. 38° 37′, long. 90° 15′), *by* A. FENDLER.

Aug. 28th, at $8^h\ 30^m$ P. M. I observed in the northern part of the sky some large patches of a deep red color, and the horizon towards the north was filled with a white light. The white as well as the red light rose gradually up to 45°. At $8^h\ 35^m$ the upper part of the light to the right was of an unusually deep red, while that to the left was greenish white. The aurora increased in splendor till $8^h\ 50^m$, rising to the zenith, with red streamers running nearly N. and S. The aurora now declined in the north, but spread its red color to about 10° south of the zenith. By 9 P. M. the red color was gone, only a faint white light remaining near the northern horizon, which continued till $9^h\ 20^m$ when it became obscured by clouds.

Aug. 29th at 1 A. M. I awoke and found the aurora more brilliant than last evening. It reached 45° south of the zenith, and had a corona 15° or 20° south of the zenith, of a deep fiery red, sending rays in all directions from this point towards the horizon. Towards the north the light was white, and close to the northern horizon the sky was blue. By $1^h\ 20^m$ the aurora had retired to within 80° above the northern horizon.

23. *Observations at Fredericksburg, Virginia,* (lat. 38° 30′ long. 77° 30′), *by* CHARLES H. ROBEY.

Aug. 28th, a most brilliant light appeared 8 P. M. and disappeared about $4^h\ 15^m$ A. M. It was generally diffused over the face of the heavens with a brightness exceeding that of the full moon, the brightest part being N.E. and N.W. About N.E. it was of a red color.

24. *Observations at the eastern base of the Sierra Abajo, Utah*, (lat. 38°, long. 110°), *by* Dr. JOHN S. NEWBERRY.

Aug. 28th—being at an elevation of about 7000 feet above the sea, from 11 to 12 o'clock the aurora appeared remarkably brilliant, the entire northern heavens being covered with a diffused red flush, with flashes of deeper red and white light. The auroral flush was noticeable in the north before 10 o'clock, but was not conspicuous before 11.

25. *Observations at Santa Clara, California*, (lat. 37° 18′, long. 122° 0′), *by* OLIVER S. FRAMBES.

Aug. 28th, at 9 P. M., about 10° E. of north the sky seemed tinged with red light. In half an hour several columns of mellow light were formed which rose to a height of 40°, and the colors became very bright. The light gradually moved to the east, and after two hours or more gradually faded away.

26. *Observations at Paducah, Kentucky*, (lat. 37° 5′, long. 87° 21′), *by* A. MATTISON.

Aug. 28th, at midnight, the clouds cleared off and showed the most beautiful aurora I ever saw in this latitude. Sometimes it was red, and sometimes it sent up streamers overhead. Aug. 29th, 1 A. M., aurora very bright, but the sky became overcast. The light continued till near day break.

27. *Observations at Monterey, California*, (lat. 36° 36′, long. 122° 54′), *by* Dr. C. A. CANFIELD.

Aug. 28th—a very brilliant aurora from 9½ P. M. to 11 or 12 P. M.

28. *Observations at Raleigh, North Carolina*, (lat. 35° 40′, long. 78° 52′) *by* WILLIAM H. HAMILTON.

Aurora appeared at 9 P. M. and lasted till 11 P. M. As light as if the moon was shining.

29. *Observations at Dallas, Texas*, (lat. 32° 45′, long. 96° 46′), *by* JOHN M. CROCKETT.

Aug. 28th, at dark the northern sky had the appearance of bright twilight. It continued to brighten until it extended from N. to N. E., and assumed a red tinge, with columns perpendicular to the horizon, and extending more than half way up the heavens. About the time of the greatest illumination, a round body in the N. E., about 15° in diameter, became of a beautiful bright scarlet, which in 20 or 30 minutes moved slowly towards the north, displacing the columns as it went. The whole scene occupied about one and a half hours and was constantly changing. The aurora continued with diminished brightness till near daylight.

30. *Observations at Selma, Alabama*, (lat. 32° 25′, long. 86° 51′), *by* S. K. Jennings, M.D.

Aug. 28th, about 8 P. M., there was a very well defined arch of red fleecy looking clouds extending up about 20°, that was beautifully brilliant for half an hour. From 8½ till after 10 P. M. there were incessant flashes that might have been taken for diffuse lightning.

31. *Observations at Cahawba, Alabama*, (lat. 32° 19′, long. 87° 16′), *by* Matthew Troy, M.D.

Aug. 28th, from 8 to 9 P. M., a bright light was visible a little east of north. It was brightest near the horizon, and extended to a height of about 30°, gradually fading at its upper border.

32. *Observations at Jacksonville, Florida*, (lat. 30° 15′, long. 82° 0′), *by* Dr. A. J. Baldwin.

Aug. 28th, about 8 P. M. was seen a remarkable aurora which continued until 2 A. M. Aug. 29th. At times it was of a vivid red, with streamers radiating towards the zenith. The brightest were from N.W. to N.E. The color would almost fade out at times, and then lighten up the heavens again with a brilliancy which was majestic. About 9 o'clock there was a dark cloud in the north extending from N.W. to N.E.; and the auroral display was beautiful along the fringe of this cloud.

33. *Observations at Micanopy, Florida*, (lat. 29° 35′, long. 82° 18′), *by* James B. Bean.

Aug. 28, just after dark I noticed a luminous appearance in the north, which at times disappeared and then reappeared with increased brightness, till 9 o'clock, when it exhibited streamers shooting up toward the zenith, and sometimes a deep red glare of rosy light toward the N.E. At 10 P. M. the streamers were quite distinct, presenting beams of gray and purple light. It disappeared about 11 P. M. but reappeared with more beauty between 1½ and 2 A. M. The streamers were very distinct, exhibiting various colors, and shooting at times within 10° or 15° of the zenith. The luminous haze in the N.W. continued till it was obscured by day-light.

34. *Observations at Cedar Keys, Florida*, (lat. 29° 7′, long. 83° 2′), *by* Judge Aug. Steele.

Aug. 28th, occurred an aurora, brightening up the northern horizon with most beautiful coruscations. It extended from N. to N.E. and upward to about 30° above the horizon, and exhibited frequent streaks of reddish yellow, shooting upward in pointed forms of the most dazzling brightness. It ceased about 9½ P. M. but reappeared the next morning in still greater brilliancy and continued until overpowered by the light of day.

35. *Observations at Corpus Christi, Texas*, (lat. 27° 45′, long. 97° 30′), *by* A. M. Lea.

Aug. 28th, about 9 P. M. an aurora reddened the sky in the north, through about 90° of the horizon, and rising about 40° above it, with columns of light stretching from the horizon towards the zenith.

36. *Observations at Key West, Florida*, (lat. 24° 33′, long. 81° 48′), *by* William C. Dennis.

Aug. 28th the aurora was faintly visible soon after sun-down and did not increase materially in brightness till 8½ P. M. At 9 P. M. the color was of the most fiery red. The direction of the middle point of the aurora was N. 10° E. and both horizontally and vertically it subtended an angle of about 30°. There was a narrow line of immovable clouds along the northern horizon in the direction of the aurora. At 9 P. M. the aurora commenced fading rapidly, and had disappeared at 9¼ P. M.

Observations on the Aurora of Sept. 1st and Sept. 2nd, 1859.

Selected from the Smithsonian Papers.

1. *Observations at St. Johns, Newfoundland*, (lat. 47° 35′, long. 52° 38′), *by* E. M. J. Delaney.

Sept. 1st, an Aurora of various colors appeared in the west, moved towards the zenith and disappeared.

Sept. 2d at 8 P. M. an Aurora of various colors appeared in the north, south and west, moved towards the zenith and disappeared.

2. *Observations at Burlington, Minnesota*, (lat. 47° 1′, long. 92° 30′), *by* A. H. Hibbard.

Sept. 2d, Aurora commenced at 8 P. M. in the north, and N.E.; increased very fast until 8½ P. M. when it formed a perfect arch frrom N.E. to S.W. and ran about one-third of the way down from the zenith on the south side. The east and west parts were very red; the east part flashy like lightning. At 9 P. M. nearly disappeared. At 9¼ P. M. commenced in the north with very bright and flashy light; then very bright streamers ran up instantly almost to the zenith. At 9½ P. M. nearly disappeared; only bright flashy spots E. and N.W.

Sept. 3d, Aurora commenced about 8½ P. M.; beams ran up very rapid but very dim; formed perfect at about 9½ P. M.

3. *Observations at Princeton, Minnesota*, (lat. 45° 50′, long. 93° 45′), *by* O. E. Garrison.

Sept. 2d, a bright aurora extending from the N.W. to the E. and culminating in the zenith. It was a bright display of streamers in bands varying from a bright white to a red flame

color; the portion on the eastern extremity was flashing rather than streaked; that on the west was of a reddish flame color. The bands were about two degrees wide reaching from the horizon to the zenith. The central portion of each band being brightest, diminishing to a slight light on the edges. The first appearance was at dark, and it was still bright at 10 P. M.

Sept. 3d, the Aurora was repeated, but much less brilliant and and only about 45° elevation with a dark arch beneath about 20° above the horizon. Disappeared before 9 P. M.

4. *Observations at Gardiner, Maine*, (lat. 44° 11′, long. 69° 46′), *by* R. H. GARDINER.

Sept. 1st, brilliant aurora over dark arch.

Sept. 2d, very remarkable aurora. Colored streamers with constant, and very brilliant flashes of light at north and east, and reaching south of zenith. At 9½ P. M. two very bright arches at the north, one about 12° the other about 25° above the horizon, the upper one being extremely bright; the sky between them and below the lowest, being of a dark purple.

Sept. 3d, very brilliant aurora with colored streamers in all parts of the sky.

5. *Observations at Ogdensburg, New York*, (lat. 44° 43′, long. 75′ 26°), *by* W. E. GUEST.

Sept. 2d, at 1 A. M. a splendid aurora. The light continued for nearly two hours.

Sept. 2d, 9½ P. M. A few faint streamers shot up in the east and at the same time there was a faint rose colored light in the west, when all at once there commenced on every side a display of waves of auroral light. It was an undulating motion commencing near the horizon, and waving up gradually toward the zenith. In ten or fifteen minutes it had reached the zenith, and a corona was formed, its rays of different lengths pointing downward. It disappeared almost as rapidly as it came on, and a faint light was spread on all sides. A few minutes before ten a large arch was formed, one extremity resting in the east, and the other in the N.W. Its base was dark, yet the stars were glittering through its whole length. The arch was somewhat irregular in form in the N.W. It rose gradually until a faint double arch was formed. The streamers were quite stationary, without any motion from right to left. In less than an hour it had lost its form, and the light was diffused throughout the glittering dome. There was some light continued through the night.

6. *Observations at Salem, Oregon*, (lat. 44° 58′, long. 123° 4′), *from the Statesman.*

Sept. 1st, about 8 P. M. a faint radiance was observed shooting up from the northern horizon, and gradually the whole heavens

from north to south were covered with a delicate rosy tint, bright and glowing in the zenith, and decreasing in brilliancy near the horizon. It was most brilliant about 11 P. M. at which time it yielded sufficient light to read common print quite easily. It continued to shine with gradually decreasing splendor, and finally yielded as morning approached.

7. *Observations ot Fort Umpqua, Oregon*, (lat. 43° 48′, long 124° 6′), *by* HENRY OATLEY, U. S. Army.

An aurora was observed on the night of Sept. 1st. The light was most intense about midnight, and was sufficient to enable one easily to read print.

8. *Observations at Rochester, New York*, (lat. 43° 8′, long. 77° 51′), *by* M. M. MATHEWS.

Sept. 2d, $1^h\ 45^m$ A. M. the southern sky was one entire sheet of red light, extending from near the zenith, quite down to the horizon, and reaching laterally from S.E. to N.W. At 2 A. M the redness gathered intensity, and divided off into two nearly equal portions, one occupying the S.E. and the other the N.W. section of the sky, and for half an hour assuming a deep cherry red hue, with an occasional streamer of white light ascending nearly or quite to the zenith.

At 3 A. M. the whole sky from N.W. around to the S.E. became one entire blaze of deep red, and began sending off from all portions of its lower margin, the most brilliant streamers of white light which waved and flickered in front of the dark red back ground. They converged to a point just south of the zenith. This corona was most distinct at $3^h\ 15^m$ A. M. when it presented the appearance of an immense fan resting on the horizon. At the north lay a heavy bank of cloud rising about 2° above the horizon, and during the most brilliant display at the south, the upper edge of these clouds was tinged with a most beautiful orange color. At $3^h\ 30^m$ A. M. the redness had become comparatively faint, and the streamers had entirely disappeared.

Sept. 3d, about 8 P. M. was another auroral display confined mostly to the northern sky, and consisting principally of white streamers that were constantly flickering and dancing. At 9 P. M. they reached a point south of the zenith, and were attended by flashes of extreme brightness. At 11 P. M. the light had become quite faint, and the the streamers had disappeared.

9. *Observations at Ostego, Michigan*, (lat. 42° 28′, long. 85° 42′), *by* MATTHEW COFFIN.

Sept. 2d, aurora brightest about 2 A. M. when there was a beautiful corona a little S.W. of zenith, and rapidly shooting rays from N.W. and N.E. meeting at that point.

10. *Observations at Riley, Illinois*, (lat. 42° 11′, long. 88° 33′), *by* E. Babcock.

Sept. 1st, 11 P. M. aurora displaying beautiful red and white streamers covering all the northern half of the heavens. At midnight the whole north was covered with beautiful streamers of varied colors. At $12^h\ 15^m$ A. M., streamers shot up from the north; the whole moved south and rested about 20° above the southern horizon, at which time a dark belt appeared under the white. Immediately streamers shot up from all around the horizon centering near the zenith. The deep red prevailed at S.E. and N.W. In less than two minutes, the whole became a broken mass, and the streamers disappeared. The dark belt still rested upon the southern horizon, and the light continued all over the heavens.

11. *Observations at Davenport, Iowa*, (lat. 41° 30′, long. 90° 38′), *by* H. J. Finley

Sept. 2d, 8 P. M. aurora in brilliant reddish parallel rays running east and west about 45° above the northern horizon. Corona pale and but few rays.

12. *Observations at Camp, No.* 33, *Nebraska*, (lat. 42°, long. 109° 50′) *by* Capt. J. H. Simpson.

Sept. 1st, at 11 P. M. about two thirds of the whole southern heavens appeared one sheet of beautiful roseate light. For a while, the light continued in a state of repose; the most concentrated portion forming a limiting belt on its northern side, and extending from a point on the horizon about 10° north of east, across the heavens to a point on the horizon about due west. From this belt, the light with its roseate hue was diffused southwardly all over the heavens down to the arc of a circle whose plane was inclined to the horizon about 10°. At length the light assumed a more intense form and shot up in whitish coruscations to the apex of the illuminated portion which was about 20° south of the zenith. My assistant observed this aurora at 10 P. M., and as it disappeared about midnight it must have lasted about two hours.

13. *Observations at Great Salt Lake City, Utah*, (lat. 40° 45′, long. 111° 26′), *by* W. W. Phelps.

An aurora was seen here on the evening of Sept. 1st and morning of the 2d. A little after midnight, it spread from north to south, from east to west; and by its light I could tell the time on my watch. There was a beautiful center equally rayed near the zenith. At times the southern hemisphere began with pale red at the zenith, and faded down to a dark orange horizon, while the northern hemisphere glowed with yellow and green. I continued my observations till past 2 A. M.

Sept. 3d, about 8 P. M. a faint light sprung up in the east, and rose about 45° high. At $9^h\ 15^m$ it glowed beautifully. After 10 P. M. it grew fainter, and disappeared a little after midnight.

14. *Observations at New York City*, (lat. 40° 43′, long. 74° 5′), *by* Prof. O. W. MORRIS.

Aurora from $10^h\ 20^m$ P. M. Sept. 1st, till dawn of the 2d. There was a dark band at the south of 10° or 15°, then a white one and streamers of a variety of colors, mostly red, shot up in the S.E. and yellow in the S.W. interspersed with white beams. The corona was after 1 A. M. a little S. E. of the zenith.

Sept. 2d aurora from 10 P. M. to $11^h\ 15^m$ P. M. At first a faint light, then a dark segment above it on the northern horizon of about 15° in breadth; above it a band of about 8°; then another dark band, surmounted by a white one from which beams of bright light shot up along the upper edge. About $10^h\ 15^m$ waves of white light shot up nearly to the zenith. It faded away gradually after 11 P. M. retaining only a steady light on the horizon.

15. *Observations at Carlisle, Pennsylvania*, (lat. 40° 12′, long. 77° 11′), *by* Prof. C. W. WILSON.

Very brilliant aurora lasting from midnight to 3 A. M. Sept. 2d. Also Sept. 2d, 9 P. M. It first appeared as a luminous arch extending from N.W. to N.E. and 10° or 20° high. From this the light shot up in streamers first white, then turning bright red about half way to the zenith. The arch finally disappeared and, the whole then presented the appearance of a mass of light clouds, with rapid flashes behind them. The whole lasted about half an hour.

16. *Observations at Urbana, Ohio*, (lat. 40° 6′, long. 83° 11′), *by* Prof. M. G. WILLIAMS.

Sept. 2d, my first observation was at $1^h\ 30^m$ A. M. when the entire northern heavens were covered with a uniform yellowish light. There was also a large mass of crimson light in the S.W. At 2 A. M. the whole south was covered with pink and crimson light, soon after a distinct and beautiful corona was formed a few degrees south of the zenith, and continued about 15 minutes. At $2^h\ 40^m$ A. M. a beautiful column of light 12° in breadth white, yellowish, pink and crimson rose from the west at an angle of 70° with the southern horizon. At 3 A. M. the aurora was considerably diminished in intensity, but continued with variations till dawn of day.

Sept. 2d, at $8^h\ 45^m$ P. M. the light was distinct and uniform along the northern horizon. At $9^h\ 15^m$ there were fine coruscations increasing in brilliancy till 10^h. At $9^h\ 30^m$ the coruscations had for their base a well defined arch extending from N.

80° E. to N. 85° W., and its altitude at its center was 12°. Many of them reached the zenith but no corona was formed. The coruscations were mostly white.

Sept. 3d. The evening was cloudy, but the aurora was sufficiently strong to illuminate the clouds.

17. *Observations at Newark, Ohio*, (lat. 40° 4′, long. 82° 23′) *by* DAVID WYRICK.

Sept. 1st, about midnight the entire heavens except near the southern horizon were illuminated by a pale yellow light. In about ten minutes masses of red light appeared in the E. and W; and as they faded away others appeared in the N. and S. Subsequently there was a beautiful emanation of red rays from a circular center near the zenith. The whole phenomenon lasted about two and a half hours. In the S. and S.W. lay a dark cloud rising about five degrees above the horizon.

18. *Observations at Baltimore, Maryland*, (lat. 39° 18′ long. 76° 37′), *by* C. WESTBROOK, *Telegraph Superintendent.*

On the morning of Sept. 2d, I found the telegraph wires charged to an extent far beyond the strength of our ordinary batteries. Upon disconnecting the batteries I got clear and distinct writing from Cumberland, distant 179 miles. When the current was at its maximum strength, the manipulations of the operator at Cumberland worked the armature of the relay magnet here with a force nearly equal to that which would be produced by a Grove battery of 50 cups on a short circuit. The intensity of the spark at the instant of breaking the circuit, was such as to set on fire the wood work of the switch board. The current however was variable, and at times no sensible effect could be observed.

19. *Observations at Aurora, Indiana*, (lat. 39° 4′, long. 84° 54′), *by* GEORGE SUTTON, M.D.

Sept. 1st, about 10 P. M. a faint aurora was seen in the north; and about midnight the aurora extended over the whole heavens. In the north the light was of a pale color resembling the break of day, and a few faint streamers could be seen. About 1 A. M. the whole southern heavens presented a deep red appearance. At $1^h\ 30^m$ streamers were more frequently seen in the north, and occasionally a ray would appear in the S.E and S.W. Between 2 and 3 A. M streamers arose in all directions, but much paler in the north than in the south. The streamers converged to a point presenting the appearance of a vast and gorgeous tent. From 1 A. M. until the break of day, the most brilliant display was in the south.

Sept. 2d, about 8½ P. M. the aurora appeared again in the north. There were occasional flashes of light resembling distant lightning. It disappeared in a few hours.

20. *Observations at Auburn, California*, (lat. 38° 53′, long. 121° 2′), *by* ROBERT GORDON.

Sept. 1st, from 9½ P. M. until daylight we had a most magnificent display of aurora, in which the whole sky north, south, east and west was almost all the night glowing with ruddy light. The northern point near the horizon where the aurora commenced continued rather dark.

21. *Observations at St. Louis, Missouri*, (lat. 38° 37′, long. 90° 15′), *by* A. FENDLER.

Sept. 2d, at 8^h 20^m P. M. the aurora exhibited a white hazy light 15° above the northern horizon. Soon long white streaks appeared alternately on the right and left to 45° above the horizon, and a light red tint was sometimes visible. At 8^h 30^m the aurora disappeared. At 9^h 20^m P. M. it again threw out several white streaks to about 60° above the northern horizon. Presently it changed to a few fiery red spots. At 9^h 27^m a few short streaks shot up a little to the east of north. At 9^h 32^m the aurora became brilliant. At 9^h 34^m red with no streaks. Soon after nothing remained but white diffused light.

22. *Observations at Moneka, Kansas*, (lat. 38° 30′, long. 98°), *by* L. CELESTIA WATTLES.

Sept. 2d, an aurora appeared from 1 to 3 A. M. On the same night about 10 P. M. a light appeared in the S.E. like the rising of the moon. It grew redder and more brilliant as it extended up the sky until it reached the zenith. It now shot out to the westward, streaming continually across the sky to the horizon. It did not wholly disappear until the morning dawn.

23. *Observations at New Albany, Indiana*, (lat. 38° 17′, long. 85° 45′), *by* ALEXANDER MARVIN.

Sept. 2d, at 1^h 30^m A. M. a broad beam of crimson light extended up from the eastern horizon and met another from the west considerably south of the zenith. Beautiful streamers shot up all around the north to the point of meeting of the beams, south of the zenith. In the north a dark cloud extended from E. to W. in the form of a flat arch. Above it was an ever changing display of white and deep crimson streamers. A similar arch of cloud was visible in the south but not quite so flat; and above it, streamers concentrated in the point above mentioned. The greatest observed brilliancy was from 1^h 50^m to 2^h 30^m A. M.

Sept. 3d, 8^h 45^m P. M. streamers of white and pale red light shot from the horizon half way to the zenith. At 9 P. M. only a grey light in the north.

24. *Observations at Louisville, Kentucky*, (lat. 38° 3′, long. 85° 30′), *from the Louisville Journal.*

On the morning of Sept. 2d for some three hours commencing about midnight, the whole heavens were lighted up in the most brilliant manner. The light was generally diffused over the whole sky, but was reddest in a southwest direction. Towards the north it was whiter with occasional streaks of green and deep crimson darting up towards the zenith.

25. *Observations at the base of the Sierra Abajo, Utah*, (lat. 37° long. 110°, *by* Dr. JOHN S. NEWBERRY.

Sept. 1st, no aurora was observed at 9 P. M. the heavens being partially obscured by broken clouds. At 1 A. M. I waked and was startled by the red light that penetrated the tent and tinged the landscape, which was illuminated as strongly as by the full moon shining through thin clouds. On going out I found the whole heavens of a bright crimson with streaks of white and yellow converging toward the zenith, where they formed a beautiful corona. These rays reached down within 20° of the southern horizon. The aurora continued almost without abatement till day-light.

26. *Observations at Bentonville, Arkansas*, (lat 36° 22′, long 94° 16′), *by* PAUL GRAHAM.

Sept. 1st, at 11 P. M. there was a bright sheet of light embracing the eastern and northeastern part of the horizon, from thence extending upwards 60°. It became so light that objects were clearly seen at a considerable distance. At the same time, the clouds in the S. W. were tinged with red. It continued very bright until 3 A. M. at which time it disappeared.

27. *Observations at Asheville, N. Carolina*, (lat. 35° 37′, long. 82° 29′), *by* H. H. STRAWBRIDGE.

Sept. 2d, at $12^h\,30^m$ A. M. my attention was attracted to a singular fiery light in the N.E. at an elevation of about 45°. Some 3° or 4° to the east of north also apppeared a space of whitish light. Both lights increased, the spots of faint reddish light extending quite to the zenith. At $12^h\,50^m$ the lights diffused themselves over the sky, and from about N.E. to S.W. a complete belt of roseate light extended from horizon to horizon across the zenith. It was at first about 6° or 8° in breadth, its edges very ill-defined; but it gradually widened and changed its line of direction until it became a zone of rosy light from 25° to 40° in breadth, reaching from the west to a little north of east. From $1^h\,5^m$ to $1^h\,25^m$ A. M. I was able to read with perfect ease the smallest type in a newspaper. At $1^h\,30^m$ the light slightly decreased. At 2 A. M. a large space in the belt about E.S.E. and 50° above the horizon became more intense. From $2^h\,30^m$ the clouds so thickened as to prevent observations, although the red zone was still clearly traceable.

28. *Observations at Memphis, Tennessee*, (lat. 35° 8′, long. 90° 0′), *by* R. W. MITCHELL, M.D.

Sept. 1st, at midnight a splendid aurora flamed up suddenly in the north. Its breadth was about 30°, extending 15° on each side of the meridian and its altitude was about 40°. At first its color was nearly blood red, and motionless; but about $12^h\ 30^m$ A. M. streamers began to appear though with little or no change of color. In less than an hour the deep red began to fade, and it continued thus until 4 A. M. when it vanished.

29. *Observations at Selma, Alabama*, (lat. 32° 25′, long. 86° 51′), *by* S. K. JENNINGS, M.D.

Sept. 2d, about $12\frac{1}{2}$ A. M. a strip of red cloud nearly transparent and 9° or 12° wide commenced in the east, and soon extended across to the west, forming a magnificent arch. It was striped with the various hues of red from light to brightest scarlet, with a tinge of straw color, and from the centre of the arch diverging rays looking to the south and reaching nearly to the horizon. The rays colored like the arch were soon scattered, but the main arch did not entirely disappear until $4\frac{3}{4}$ A. M.

30. *Observations at Paulding, Mississippi*, (lat. 32° 20′, long. 89° 20′), *by* Rev. E. S. ROBINSON.

Sept. 2d, at $2^h\ 10^m$ A. M. nearly the whole visible heavens were overspread with a gauze-like lurid tint which continued till $3^h\ 30^m$ A. M. It was most brilliant in the N. E. and N. W. and at $2^h\ 30^m$ extended thirty degrees south of the zenith.

31. *Observations at Cahawba, Alabama*, (lat. 32° 19′, long. 87° 16′), *by* Dr. MATTHEW TROY.

Sept. 2d, the aurora was first observed about 1 A. M. An arch spanned the heavens from E. to W. a few degrees south of the zenith. To the north the sky had a distinct greenish tinge. The most magnificent displays of colored light were nearly over head. The light was so great that fine newspaper print could be read by it; and it continued with varying brilliancy till obscured by daylight.

32. *Observations at Natchez, Mississippi*, (lat. 31° 34′, long. 91° 25′), *by* J. J. SCOTT.

Sept. 1st, the aurora commenced at 10 P. M. I began to observe it at $12^h\ 15^m$ A. M., Sept. 2d. A glowing arch of the deepest crimson and 8° or 10° in breadth, extending from the N.E. to the N. W. points of the horizon, rising to the height of about 40°, while a fainter arch appeared below it. At $12^h\ 30^m$ rays emanated in all directions except south of a great circle passing through a point situated in the wing of Pegasus. From this point issued a broad flare of light which waved like a pennant. Every

where in the northern sky, patches of light would appear, glow for a time and gradually disappear. These appearances continued throughout the night, growing fainter as the dawn approached.

33. *Observations at Wheelock, Texas*, (lat. 30° 55′, long. 87° 29′), *by* F. Kellogg.

At 10 P. M. Sept. 1st, I first observed a zone of crimson light 30° in breadth, reaching from 10° above the horizon due east, vertically overhead, and terminating 10° above the horizon due west. From the zenith to the eastern extremity of the zone the light was mild, the color increasing in intensity toward the east, until within 15° of the horizon where it gradually faded. At $11^h\,20^m$ a beam of whitish light passed due north through the zenith. At $11^h\ 30^m$ another beam diverged from the former to the west, making an angle with it of 40°. These two beams, if continued, would unite about 25° south of the zenith. At midnight the entire space between these beams was filled up with similar but shorter beams of light, converging toward each other. Soon these central rays began to shoot bright scintillating rays of white light from their northern and western ends which travelled with great velocity. The eastern boundary of the zone became gradually paler until $12^h\ 30^m$ A. M. Sept. 2d, when the color in that direction entirely disappeared, and the brightest light was then in the west and northwest. At 1 A. M. the crimson color had entirely disappeared, and nothing remained but the fan-like appearance of the numerous divergent beams of white light. The two rays first formed never changed their form or position until they disappeared about 2 A. M.

34. *Observations at Thomasville, Georgia*, (lat. 30° 50′, long. 84° 0′), *by* W. Blavett.

Sept. 2d, about 2 A. M. the whole northern half of the heavens was beautifully illuminated. The daily track which the sun now describes formed the southern boundary of the illuminated portion of the heavens. Upon this southern boundary was a border of deep blood red light, of 2° or 3° in breadth, extending from the eastern to the western horizon. Streams of pale light diverged from the point where this band cut the meridian. These pale streamers, at one moment, were numerous, and the next moment scarce a trace of them could be seen. The great red belt sometimes changed to a beautiful orange color.

35. *Observations at Mobile, Alabama*, (lat, 30° 41′, 88° 1′), *from the Daily Mercury.*

Sept. 2d, the aurora appeared at midnight and soon after 1 A. M. the eastern sky seemed bathed in a flame of lurid light, while a yet deeper flame streaked with silvery beams the N.W. These two pillars were united in the zenith, by a broad belt of

dimmer fire. The pyramidal foci of red light were situated, one in the east, the other in the N.W. A little later the red field in the N.W. extended southerly so that one half the western sky from the horizon to the zenith seemed a blaze of fire. Meantime brilliant streamers continued to shoot from the N.E. and N.W. towards the zenith, sometimes extending over 50° or 60° of the heavens. These streamers converged towards a point on the meridian about 15° south of the zenith, and from this point shot forth smaller pencils of silvery showers. At $3^h\ 30^m$ the play of the streamers had ceased, while the flash of fiery red had spread over the whole north. The red flush in the northern quarter of the heavens, continued to glow until obscured by the solar dawn.

36. *Observations at Washington, Texas*, (lat. 30° 26′, long. 96° 15′), *by* Maj. B. F. Rucker.

Sept. 1st, at $10^h\ 30^m$ P. M. I observed a bright light in the north and N.E. At $11^h\ 30^m$ the light had become much stronger and a good deal more extended in the base; and some beautiful rays shot far up on the sky in the north. At midnight the base of fiery looking vapor extended from N.E. to N.W. The rays of fiery colored light rose from every direction like an inverted fan and converged towards a point several degrees south of the zenith. Some of these rays appeared like immense columns; others only as a thin streak; some were pale, others fiery. At 1 A. M. the light continued undiminished, although the darting rays were not so numerous. The aurora continued until obscured by the light of the sun.

37. *Observations at Jacksonville, Florida*, (lat. 30° 15′, long. 82°), *by* Dr. A. J. Baldwin.

Sept. 2d, the aurora was witnessed from midnight till daylight. At 3 A. M. the entire heavens, even at the extreme south were in a red glow. Streamers ran up from a point in the N.W. and from the S.E. and tortuous waves swelled up from the bottom of these streamers and illuminated the whole heavens. At times these looked like lambent flames, flickering like a blaze of fire.

38. *Observations at Union Hill, Texas*, (lat. 30° 11′, long. 96° 31′), *by* Dr. Wm. H. Gantt.

Sept. 1st, at 11 P. M. a faint glimmering light was visible in the N.E., which gradually grew brighter and extended over a larger space. At midnight it reached from the north 35° eastward, and mounted nearly to the zenith, and soon began to be seen west of north. At 1 A. M. it extended from west to east, and beyond the zenith. Towards the north, extending east and west about 20°, and rising about 10° above the horizon was a dark looking cloud. Above this, the light was of a whitish color, and

from it sprang streamers of pink merging into crimson. The grandest display was from 1 A. M. to $1^h\ 35^m$. It now began to fade, and at $3^h\ 30^m$ was nearly gone. A few flashes of it, however, remained until daylight.

39. *Observations at Micanopy, Florida*, (lat. 29° 30′, long. 82° 18′), *by* JAMES B. BEAN.

Sept. 2d, at $12^h\ 30^m$ A. M. I first saw a luminous haze in the north, and at $12^h\ 35^m$ streamers shot up in the north. A few minutes before 1 o'clock a luminous arch appeared, but not well defined. At 1 A. M. it included 160° of the horizon; at $1^h\ 10^m$ there were many distinct streamers; at $1^h\ 15^m$ beautiful quivering streamers, while patches of white light appeared in different parts of the northern hemisphere. At $1^h\ 25^m$ the corona was very bright; at $1^h\ 35^m$ corona very distinct, of vivid white clouds of light. At $1^h\ 40^m$ very brilliant red beams in the west; at $1^h\ 50^m$ the arch extended from E. to W. passing through Aries and Pegasus; at 2^h a faint corona; at $2^h\ 11^m$ distinct beams near the zenith and on each side E. and W.; at $2^h\ 25^m$ arch brighter red with red patches of light and distinct streamers reaching beyond the zenith; at $2^h\ 35^m$ arch fading, at $2^h\ 40^m$ red light in N.W. but streamers not so distinct; at $2^h\ 50^m$ beautiful beams in N.E.; at 3^h arch disappearing, beams indistinct; at $3^h\ 10^m$ red haze and no beams; at $3^h\ 30^m$ very faint red haze, and faint white light near the horizon.

40. *Observations at Corpus Christi, Texas*, (lat. 27° 45′, long. 97° 30′), *by* A. M. LEA.

Sept. 1st, the aurora began about $11\frac{1}{2}$ P. M, and continued until daylight. Two-thirds of the whole visible heavens were lighted up with a rich red glow, whilst the tremulous columns of variegated light swept over the heavens, from the northern horizon through the zenith to a line within 40° of the horizon on the south. Its greatest intensity was about $1\frac{1}{2}$ A. M. Sept. 2d.

41. *Observations at Fort Jefferson, Florida*, (lat. 24° 37′, long. 82° 52′), *by* Capt. D. P. WOODBURY.

Sept. 2d, at $12^h\ 45^m$ A. M. a continuous arch of red color extended from N. 50° E. to N. 50° W. having an altitude of about 15°, and the thickness of the arch throughout was about 25°. The shade of red was deepest along the central part of the arch, gradually diminishing above and below. Soon rays began to appear in faint white lines; they grew brighter, and extended above and sometimes a little below the arch. Soon the rays became numerous, traversing the red arch in right lines, and converging to a point in the magnetic meridian somewhat south of the zenith. They sometimes extended as high as the zenith, and even beyond. The aurora continued, gradually fading, till day light.

42. *Observations at Key West, Florida*, (lat. 24° 33′, long. 81° 48′), *by* WILLIAM C. DENNIS.

Sept. 2d, at 2½ A. M. there were two patches of brilliant ruddy lights one in the N.E. and the other in the N.W. From the North extending 15° toward the E. there were rays of light shooting toward the zenith, the longest reaching full 60°. At $2^h\ 50^m$ the patch of light in the N.E. broke up into most brilliant rays extending toward the zenith. At 3 A. M. the patch of light in the N.W. also broke up into rays of light in a similar manner. At $3^h\ 15^m$ the rays gradually disappeared, but there still remained brilliant ruddy lights in the N.E. and N.W. At 3½ A. M. the aurora was decidedly fainter, and at 4 A. M. nothing but a faint glow remained. This glow did not entirely disappear until overcome by the light of day.

43. *Observations at Sea*, (lat. 12° 23′ N., long. 88° 28′ W.), *by* Commander W. D. PORTER, U. S. Navy.

Sept. 1st, about 11½ P. M. the sky had a lurid appearance in the north, and there were occasional flashes of lightning. The rest of the sky was clear, bright and beautifully blue. The red appearance was very much like the aurora of high latitudes, and now and then it had a wavy appearance. About 1 A. M. a body of heavy clouds passed over with rain.

ART. XXXII.—*On the direction of molecular motions in Plane Polarized Light;* by Prof. W. H. C. BARTLETT.

Fresnel's Formulas for reflexion and ordinary refraction.

IT is proposed, in the following paper, to deduce these formulas from the principle of the conservation of living force and the rules for the resolution and comparison of forces, without any hypothesis in regard to the condition of the ether in the co-terminous bodies. If this were the only object, however, the solution would hardly be worth the space asked for it in the Journal, because all now-a-days believe in the truth of these formulas. But there is a purpose beyond this. The mode of solution may settle the vexed question in regard to the direction of the molecular motions in plane polarized light; and, on this account, it will have an interest for those who are still in doubt upon the subject. There are few opinions among scientific men held more loosely than that which relates to this question. Some contend for vibrations in, and others perpendicular to, the plane of polarization; and a few of the most eminent and thorough investigators have entertained both opinions at different times,

having changed not once but twice or thrice. Although Professor McCullogh has shown, in his elaborate treatise on crystalline reflexion and refraction, as published in the memoirs of the Royal Irish Academy, vol. xviii, that vibrations in the plane of polarization are absolutely essential to the theory, still other results are adduced which lean to the opposite view, and opinions are still divided.

When a wave of a given length is plane polarized, by a single reflexion, the plane which contains the incident and reflected rays, is called *the plane of polarization.* Are the molecular vibrations, which in this case are rectilinear, performed in this plane or at right angles to it?

Take the well known wave function, say the first of Equations (528), Bartlett's Analytical Mechanics, omitting the subscripts, x,

$$\xi = \alpha . \sin \frac{2\pi}{\lambda} (Vt - r) \quad . \quad . \quad . \quad . \quad . \quad (1.)$$

in which the molecular vibrations are parallel to the axis x, and the wave propagation in the direction of the plane yz, ξ the actual molecular displacement at the time t, α its maximum value, V, the velocity of wave propagation, λ the wave length, and r the distance of the molecules place of rest from the origin.

Living force and quantity of motion in a plane polarized wave.

Differentiate eq. (1), with respect to ξ and t, we find:—

$$\frac{d\xi}{dt} = \alpha . V . \cos \frac{2\pi}{\lambda} (Vt - r) \frac{2\pi}{\lambda}.$$

Denote the density of the medium by Δ, and the area of any portion of the wave-front by a, then will the mass between two consecutive positions of this area be $a . \Delta . dr$, and the living force within a quarter of a wave-length be:—

$$\left.\begin{aligned} \int_{r+\frac{1}{4}\lambda}^{r} \Delta . a . dr \frac{d\xi^2}{dt^2} = \int_{Vt-r=\frac{1}{4}\lambda}^{Vt-r=0} \Delta . a . \frac{2\pi}{\lambda} . \alpha^2 . V^2 . \cos^2 \frac{2\pi}{\lambda} (Vt - r) \\ \times \frac{2\pi}{\lambda} dr = \tfrac{1}{2} \frac{\pi^2}{\lambda} . V . \Delta . a . V . \alpha^2. \end{aligned}\right\} \quad (2.)$$

Dividing by the volume $a . V$, and recalling that π and $\frac{V}{\lambda}$ are constant, we shall find that the quantity of living force in a unit of volume of the medium will vary directly as the product of the density and square of the greatest displacement; and the relation of these products, in the case of any two waves, will determine the relation of the effects of these waves upon the organs of sense upon which they act.

Again, the quantity of motion in this quarter of wave-length will be:—

$$\int_{r+\frac{1}{4}\lambda}^{r} \Delta.a.dr.\frac{d\xi}{dt}=\int_{Vt-r=\frac{1}{4}\lambda}^{Vt-r=0} \Delta.a.a.V.\cos\frac{2\pi}{\lambda}(Vt-r)\frac{2\pi}{\lambda}dr=\Delta.a.a.V. \quad (3.)$$

Resolution of living force and of motion, by deviating surfaces.

Take the co-ordinate plane $x\,z$ in the plane of incidence, and the axis z in the direction of the normal to the incident wave, the axis y will be parallel to the line of the nodes of the molecular orbit in the deviating surface, at the place of incidence. Then denoting any portion of the trace of the plane of incidence on the denoting surface by s, and the angle of incidence and of reflection by φ and φ', respectively, will the element of the deviating surface at the place of incidence be $ds.dy$, and its projections upon the incident, reflected, and refracted wave-fronts, respectively, be $ds.dy.\cos\varphi$, $ds.dy\cos\varphi$, and $ds.dy.\cos\varphi'$. These will take the place of a in Equations (2) and (3), in computing the living force and quantity of motion in the incident, reflected and refracted waves.

Now take a wave of common light and replace it by its two components, having the vibrations in the one parallel and in the other perpendicular to the plane of incidence.

First take the component wave in which the molecular motions are parallel to the plane of incidence, and therefore parallel to the axis x, and employ the subscripts i, r and t, to denote the incident reflected and transmitted or refracted component waves, respectively. The living force in the incident, must be equal to the sum of the living forces in the reflected and refracted components; whence, equation (2), omitting the common factors,

$$\Delta.\cos\varphi.V.a^2{}_{xr}+\Delta_{,}.\cos\varphi'.V_{,}.a^2{}_{xt}-\Delta.\cos\varphi.V.a^2{}_{xi}=0;$$

or, recalling that $\dfrac{V}{V_{,}}=\dfrac{\sin\varphi}{\sin\varphi_{,}}$,

$$a^2{}_{xr}+\frac{\Delta_{,}}{\Delta}.\frac{\cos\varphi'}{\cos\varphi}.\frac{\sin\varphi'}{\sin\varphi}.a^2{}_{xt}-a^2{}_{xi}=0 \quad . \quad . \quad . \quad (4.)$$

in which Δ and $\Delta_{,}$ are the densities of the medium of incidence and of intromittance.

The molecular motions are all parallel to the plane of incidence, and at the same time normal to the directions of their respective wave motions; they, therefore, make with one another angles equal to those made by the directions of these latter motions, and we obtain two more equations from the rules for the resolution and composition of oblique forces. The angles made by the direction of the motion in the incident with the directions of the motions in the reflected and refracted waves, are $180°-2\varphi$ and $360°-(\varphi-\varphi')$, respectively; and the angles under which the

directions of the motions in the latter waves are inclined to one another, is $180°-(\varphi+\varphi')$. Whence:—

$$\Delta_{,}\cos\varphi\,.\,V_{,}\alpha_{xr}=-\Delta\,.\cos\varphi\,.\,V_{,}\alpha_{xi}\,.\frac{\sin(\varphi-\varphi')}{\sin(\varphi+\varphi')};$$

$$\Delta_{,}\cos\varphi'\,.\,V_{,}\alpha_{xt}=\Delta\,.\cos\varphi\,.\,V_{,}\alpha_{xi}\,.\frac{\sin 2\varphi}{\sin(\varphi+\varphi')};$$

or,

$$\alpha_{xr}=-\alpha_{xi}\,.\frac{\sin(\varphi-\varphi')}{\sin(\varphi+\varphi')} \quad . \quad . \quad . \quad . \quad . \quad . \quad (5.)$$

$$\alpha_{xt}=\alpha_{xi}\,.\frac{\Delta}{\Delta_{,}}\,.\frac{\cos\varphi}{\cos\varphi'}\,.\frac{\sin\varphi}{\sin\varphi'}\,.\frac{\sin 2\varphi}{\sin(\varphi+\varphi')} \quad . \quad . \quad . \quad . \quad (6.)$$

Substituting these in equation (4.), we readily find:—

$$\frac{\Delta}{\Delta_{,}}=\frac{4\cos^2\varphi'\,.\sin^2\varphi'}{\sin^2 2\varphi}=\frac{\cos^2\varphi'\,.\sin^2\varphi'}{\cos^2\varphi\,.\sin^2\varphi};$$

whence,

$$\sqrt{\Delta_{,}}=\sqrt{\Delta}\,.\frac{\sin 2\varphi}{2\cos\varphi'\,.\sin\varphi'}=\sqrt{\Delta}\,.\frac{\cos\varphi\,.\sin\varphi}{\cos\varphi'\,.\sin\varphi'} \quad . \quad . \quad (7.)$$

Substituting the above ratio of the densities in the equation just preceding, we get:—

$$\alpha_{xt}=\alpha_{xi}\,.\frac{2\cos\varphi'\,.\sin\varphi'}{\sin(\varphi+\varphi')}; \quad . \quad . \quad . \quad . \quad . \quad . \quad (8.)$$

multiplying this by equation (7), member by member, and the equation giving the value of α_{xr}, by $\sqrt{\Delta}$, and taking:—

$$\sqrt{\Delta}\,.\,\alpha_{xi}=1\,;\quad \sqrt{\Delta}\,\alpha_{xr}=v\,;\quad \sqrt{\Delta_{,}}\,.\,\alpha_{xt}=u,$$

we find:—

$$v=-\frac{\sin(\varphi-\varphi')}{\sin(\varphi+\varphi')} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9.)$$

$$u=\frac{\sin 2\varphi}{\sin(\varphi+\varphi')} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10.)$$

To which may be added the relations,

$$\sin\varphi'=\frac{\sin\varphi}{m}\,;\quad \cos\varphi'=\sqrt{1-\frac{\sin^2\varphi}{m^2}}.$$

Transposing the term of which α_{xt} is a factor to the second member in equation (4), subtracting equation (5) from $\alpha_{xi}=\alpha_{xi}$, dividing the first result by the second, and multiplying the quotient by equation (5), we readily find:—

$$\frac{\alpha_{xi}+\alpha_{xr}}{\cos\varphi}=\frac{\alpha_{xt}}{\cos\varphi'} \quad . \quad . \quad . \quad . \quad . \quad . \quad (11.)$$

That is, the projection in the direction of wave propagation and on the deviating surface, of the greatest displacement in the incident, increased by that in the reflected wave, is equal to like projection of the greatest displacement in the refracted wave.

Next, take the wave in which the molecular motions are perpendicular to the plane of incidence and therefore parallel to the axis y; these are parallel to the deviating surface. The motions in the incident, reflected and refracted waves are parallel to one another, and, by the principles of parallel forces, the sum of the motions in the reflected and refracted waves must be equal to that in the incident. The equation for the living force will be the same as before. Whence:—

$$\Delta . \cos\varphi . V . \alpha^2_{yr} + \Delta_{,} . \cos\varphi' . V_{,} . \alpha^2_{yt} - \Delta . \cos\varphi . V . \alpha^2_{yi} = 0;$$

$$\Delta . \cos\varphi . V . \alpha_{yr} + \Delta_{,} . \cos\varphi' . V_{,} . \alpha_{yt} - \Delta . \cos\varphi . V . \alpha_{yi} = 0. \quad (12.)$$

In which Δ and $\Delta_{,}$ are, as before, the densities of the medium of incidence and of intromittance, respectively; or,

$$\alpha^2_{yr} + \frac{\Delta_{,}}{\Delta} . \frac{\sin\varphi'}{\sin\varphi} . \frac{\cos\varphi'}{\cos\varphi} . \alpha^2_{yt} - \alpha^2_{yi} = 0$$

$$\alpha_{yr} + \frac{\Delta'}{\Delta} . \frac{\sin\varphi'}{\sin\varphi} . \frac{\cos\varphi'}{\cos\varphi} . \alpha_{yt} - \alpha_{yi} = 0. \quad . \quad . \quad . \quad (13.)$$

Transposing the terms containing α_{yr} and α_{yi} to the second members, and dividing the first by the second, we find:—

$$\alpha_{yr} + \alpha_{yi} = \alpha_{yt}. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (14.)$$

That is, the greatest displacement in the refracted is equal to the sum of the greatest displacements in the incident and reflected waves.

Substituting the value of $\frac{\Delta'}{\Delta}$, as given by equation (7), in equation (13), we have:—

$$\alpha_{yr} + \frac{\sin\varphi . \cos\varphi}{\sin\varphi' . \cos\varphi'} . \alpha_{yt} - \alpha_{yi} = 0. \quad . \quad . \quad . \quad . \quad (15.)$$

Substituting in this, first the value of α_{yt}, and then of α_{yr}, deduced from equation (14), we readily get:—

$$\alpha_{yr} = -\alpha_{yi} . \frac{\tan(\varphi - \varphi')}{\tan(\varphi + \varphi')}; \quad . \quad . \quad . \quad . \quad . \quad (16.)$$

$$\alpha_{yt} = \alpha_{yi} . \frac{4\cos\varphi' . \sin\varphi'}{\sin 2\varphi + \sin 2\varphi'}. \quad . \quad . \quad . \quad . \quad . \quad (17.)$$

Multiplying the first of these by $\sqrt{\Delta}$, and the second by equation (7), and making:—

$$\sqrt{\Delta} . \alpha_{yi} = 1; \quad \sqrt{\Delta} . \alpha_{yr} = v'; \quad \sqrt{\Delta_{,}} . \alpha_{yt} = u';$$

there will result,

$$v' = -\frac{\tan(\varphi - \varphi')}{\tan(\varphi + \varphi')} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18.)$$

$$u' = \frac{\sin 2\varphi}{\sin(\varphi + \varphi') . \cos(\varphi - \varphi')}. \quad . \quad . \quad . \quad . \quad . \quad (19.)$$

18. Divide equation (10) by equation (9), and equation (19) by equation (18), replace v, u, v' and u' by their values, and substitute for the ratio of the square roots of the densities its value as given in equation (7), we find:—

$$\frac{\alpha_{xt}.\cos\varphi'}{\alpha_{xr}.\cos\varphi}=-\frac{\cos\varphi'}{\cos\varphi}.\frac{\sin 2\varphi'}{\sin(\varphi-\varphi')},$$

$$\frac{\alpha_{yt}}{\alpha_{yr}}=-\frac{\sin 2\varphi'}{\sin(\varphi-\varphi').\cos(\varphi+\varphi')}. \quad . \quad . \quad . \quad . \quad (20.)$$

But $\alpha_{xt}.\cos\varphi'$ and $\alpha_{xr}.\cos\varphi$, are the components parallel to the deviating surface of the displacements which are in the plane of incidence; α_{yt} and α_{yr} are already parallel to the deviating surface; whence, as long as $\varphi>\varphi'$, that is as long as the velocity of wave-motion in the medium of incidence exceeds that in the medium of intromittance, the molecular phases in the refracted and reflected waves will be opposite, and conversely.

Denote the living force in the incident wave of common light by unity, that in each of its component waves will be denoted by half of unity; and the total living force in the reflected components will, eqs. (9) and (18), be:—

$$v^2+v'^2=\tfrac{1}{2}.\frac{\sin^2(\varphi-\varphi')}{\sin^2(\varphi+\varphi')}+\tfrac{1}{2}.\frac{\tan^2(\varphi-\varphi')}{\tan^2(\varphi+\varphi')} \quad . \quad . \quad (21.)$$

and in the refracted components, eqs. (10) and (19),

$$u^2+u'^2=\tfrac{1}{2}.\frac{\sin^2 2\varphi}{\sin^2(\varphi+\varphi')}+\tfrac{1}{2}.\frac{\sin^2 2\varphi}{\sin^2(\varphi+\varphi').\sin^2(\varphi-\varphi')}. \quad (22.)$$

If $\varphi+\varphi'=90°$, then will:—

$$\sin\varphi=m\sin\varphi'=m\cos\varphi,$$

or,

$$\tan\varphi=m;$$

in which φ is the maximum polarizing angle; the wave will therefore be wholly polarized; and since eq. (21) will reduce, in the second member, to the first term, the wave will contain those vibrations only which are parallel to the plane of incidence; that is, the vibrations will be in the plane of polarization. The intensities of the reflected and transmitted components will be, respectively, under this condition,

$$\tfrac{1}{2}\cos^2 2\varphi \text{ and } \tfrac{1}{2}\sin^2 2\varphi+\tfrac{1}{2}\tan^2 2\varphi.$$

West Point, N. Y., 1860.

ART. XXXIII.—*On some Questions concerning the Coal Formations of North America;* by LEO LESQUEREUX.

(Continued from page 74.)

Stratigraphical distribution of the Coal-flora.

DETAILS concerning the stratigraphical distribution of the coal-flora of North America, to be intelligible, ought to be prefaced by a few remarks on the order of superposition of the strata of the coal-measures.

A general section, showing the order of stratification in the whole extent of our coal-fields, would appear perhaps merely hypothetical. Such is, nevertheless, the uniformity of the distribution of the strata of our coal-basins, that a section made in Western Illinois or Western Kentucky or in any part of the coal-fields of these States, will prove comparatively similar, (that is with some difference in the thickness of the strata,) to any section made in the coal-fields of Pennsylvania or of Ohio. This analogy of stratification has been fully established by a series of comparative sections, reported for the 4th vol. of the State Geological Survey of Kentucky. Such a comparison of sections had been attempted before, for the State of Pennsylvania, by my friend J. P. Lesley, in his excellent Manual of Coal. But it was not based on palæontological evidence and thus the contemporaneousness of the juxtaposed strata was necessarily problematical. On the contrary, by admitting the similarity of the flora of the coal-strata as a coëval mark and as a basis for juxtaposition of the strata, the result of the comparison of sections gives evidence remarkable in a double point of view. First it shows, by juxtaposition of the coal strata of which the shales contain the same species of fossil plants, the uniformity of stratification in the whole area of the coal-fields of the United States; and secondly it proves that the distribution of the coal plants has followed the same developement, the same successive modification in the whole extent of the same coal-field.

Though plants of carboniferous genera are found below the upper bed of the Archimedes or mountain limestone, as, apparently, no coal has been formed at this low station, I take as the base of the true coal measures this Archimedes limestone, replaced in Eastern Pennsylvania and Northern Virginia by the red shales of the old red sandstone. From the top of the mountain limestone, to the top of the millstone-grit series, including some beds of coal at its base, the average thickness is from three to four hundred feet. The upper part of the millstone-grit series, sometimes its whole thickness, is a compound of coarse sandstone, shales and especially conglomerate, the last predominat-

ing. The conglomerate formation thickens wonderfully at some places, generally increasing westward. Its greatest thickness, in the sharp Mountain near Pottsville, Penn., is 1100 feet.*

To elucidate the details of this general section, we can admit the numbered division of the coal strata, as it has been most satisfactorily established by Dr. D. Dale Owen for the State Geological Survey of Kentucky, vol. iii, p. 18. From the top of the millstone-grit to the base of another great sandstone formation, the Mahoning sandstone, there are generally five workable beds of coal. The lowest is No. 1A; then No. 1B to No. 4 inclusively. No. 1B coal is the Big, or Mammoth coal of the East. Like the conglomerate, it increases in thickness progressively westward. The fourth bed of coal is the Pomeroy coal of Ohio. The Mahoning standstone overlying No. 4 bed of coal, like the millstone-grit is generally conglomerate at its upper part. Its thickness averages from one hundred to one hundred and fifty feet. It might, as well as the true conglomerate, be considered as the basis of a new coal epoch; even more so, perhaps, since the vegetation at its base and at its top shows a greater difference than in the coal strata above and below the millstone-grit. From the Mahoning sandstone upward, the marine influence predominates more and more and the shales of the coal strata more generally contain remains of fishes and of marine shells than of terrestrial plants. This Mahoning sandstone is separated by about 500 feet of strata from another great sandstone formation still resembling in its composition and thickness the Millstone-grit or conglomerate. It is the Anvil-rock sandstone of the State Geological Survey of Kentucky. The 500 feet of measures between it and the Mahoning, are sometimes barren of coal. But westward they contain from Coal No. 6 to No. 12, five workable beds of coal and two, scarcely if ever, of a workable thickness.† The highest coal strata of this section, Nos. 11 and 12 united together, form the great Pittsburg coal bed of Pennsylvania.

Above the Anvil-rock sandstone, there are still 500 to 700 feet of coal measures, in which some thin beds of coal are formed. But this examination of the flora of the coal measures can not be extended higher than the Anvil-rock. The upper division has been locally washed away by erosion and where it is still present, its coal beds are too thin for working and thus their unexposed shales can not be satisfactorily examined. Near Shawneetown, Illinois, the first coal above the Anvil-rock

* H. D. Rogers's final report of the State Geol. Survey of Pennsylvania, vol. i, p. 109.

† In those coal regions of the United States where coal is abundant, a bed of bituminous coal is not remunerative, when under a thickness of three and a half feet. In the Anthracite basin, the working becomes unprofitable for a bed of less than two and a half feet.

sandstone has a roof of laminated sandstone, blackened by broken and undeterminable leaves and small stems of ferns. The second bed at the same place contains only fossil shells and remains of fishes.

The first trace of a terrestrial vegetation in the Palæozoic strata of North America appears in the Marcellus shales or middle Devonian, in a species of *Lepidodendron* named *L. primævis* by Prof. H. D. Rogers.* It has not been described, but only obscurely figured by a wood-cut; and as I have not seen the specimen and could detect at the place where it has been found, near Huntingdon, only detached leaves of this species, its relation or its specific value is unknown to me. In the Devonian black shales of Ohio, and perhaps of Illinois,† large silicified trunks of trees have also been found, always very rare and at far distant localities.

Ascending higher, we find species of *Lepidodendron*, of *Sigillaria*, and especially of *Calamites* and stems (*Bornia* Sternb. and *Stemmatopteris* Göpp.) in the transition series of the Old Red sandstone of Pennsylvania, and especially in the Mountain limestone by which it is represented in the Western States. Leaves are very rare in this formation and of a different type from those of the coal measures. Heretofore, all those which have been found belong to the genus *Noeggerathia* (Sternb.), of which I have never seen a single specimen in the true coal measures.‡ Below the 3d or upper Archimedes limestone, there is in Illinois and in Arkansas a bed of schistose sandstone which, with peculiar species, already contains some others of the true coal measures. In the Cabinet of the State Geological Survey of Illinois, I have seen from this subcarboniferous sandstone, specimens of *Stigmaria anabathra* (Corda), and Göppert's varieties: *minor*, and *undulata*, *reticulata*, *stellata*; of *Lepidodendron Veltheimianum* Sternb., a species peculiar to the transition series, both in Europe and America; *of Lepidodendron Worthianum* Lsqx., a beautiful species related to *L. Volkmannianum* Sternb.; one *Lepidodendron* sp. nov.; one *Caulopteris*, one *Megaphytum*, all three new and undescribed species; *Calamites Suckowii* Brgt.; one *Bornia* Sternb.;

* Final report of the State Geol. Survey of Penn., vol. ii, p. 828.

† Mr. A. H. Worthen, State Geologist of Illinois has in his cabinet this Devonian silicified wood without label of locality. It is also in the cabinet of Dr. D. Dale Owen at New Harmony, also without label. All my specimens have been cut from a large tree protruding from Devonian strata near Delaware, Ohio, and discovered by Dr. Mann, who kindly communicated them to me. It is by all appearance the wood of a Lepidodendron, and it will be figured and described with the silicified Psaronius of the coal measures.

‡ Dr. Newberry mentions in his catalogue two species of Noeggerathia found in the coal above the conglomerate. One is *Noeggerathia Beinertiana* Göpp., a species evidently referable to *Cordaites* Ung., and probably only a small form of *Cordaites borassifolia* Ung. The other is *Noeggerathia microphylla* Newb., undescribed and consequently unknown to me.

Cordaites borassifolia Ung., *Knorria imbricata* Sternb., and some undeterminable stems. From these plants, six have been found also above the conglomerate series, ascending to coal No. 1B, or even higher. They are *Stigmaria anabathra*, var. *undulata* Göpp., and var. *minor* Göpp., *Lepidodendron Worthianum* Lsqx., *Knorria imbricata* Sternb., *Calamites Suckowii* Brgt. and *Cordaites borassifolia* Ung. These two last species are present in the whole thickness of the coal measures, as high at least as the 12th coal.

As I have said before, no coal has been seen as yet formed below the 3d Archimedes limestone. But just overlying it, a bed of coal is generally present over the whole extent of the Western coal-fields. In Arkansas, this is the only workable bed of coal, its thickness varying from 18 inches to 4½ feet. In the western part of the Eastern coal-basin of Kentucky, and also in Virginia, two, even three beds of good coal have been formed below the millstone grit. All the species of fossil plants of the shales of these coal strata have been found also in Arkansas. At Pottsville and Mauch Chunk, near the eastern margins of the coal-fields, the coal is formed between strata of conglomerate, and even at the base of this formation.

The shales of the subconglomerate coal contain not only remains of trees of large size, like the subcarboniferous sandstone, but thus early and simultaneously many of the species of ferns which become more and more abundant above the conglomerate series. Thus *Pecopteris velutina* Lsqx., *Neuropteris flexuosa* Brgt., *N. hirsuta* Lsqx., *Sphenophyllum Schlotheimii* Sternb., *Pecopteris nervosa* Brgt., *Annularia sphenophylloides* Ung., *Odontopteris crenulata* Brgt., *Cordaites borassifolia* Ung., *Hymenophyllites furcatus* Brgt.: and *Sphenopteris latifolia* Brgt., all found there in connection with it, ascend to coal No. 1B or higher. Among the trees seen in this coal, and ranging still higher in the measures, there are six species of *Lepidodendron*, two of *Sigillaria*, two *Calamites*, *Stigmaria* and its varieties, and a few species of *Carpolithes* and of *Cardiocarpon*. Though this subconglomerate coal has not been yet explored over a large area, it shows already more than twenty species, representing all the essential genera of our coal-plants, which have a wider range of distribution, and appear still in the coal strata above the conglomerate. It is therefore evident that a separation of the subconglomerate coal, as a peculiar formation and under a peculiar name, is contrary to palæontological evidence. Like every other coal bed the subconglomerate coal has species peculiar to it. Two species of *Lepidodendron*, two of *Sigillaria*, one of *Sphenophyllum*, two species of *Trigonocarpum*, one very large *Cardiocarpum*, one *Stigmaria*, one *Alethopteris*, and three or four *Sphenopteridex*.* In the shales of this lowest bed of coal, near Frog

* All the new species of this coal, or at least most of them, belong to the State Geological survey of Arkansas, and are reserved for publication in the second volume of that Report.

Bayou, Arkansas, I have found for the first time in America one of those beautiful wings of insects, referred by M. Germar to the genus *Blattina*. Though related to *Blattina didyma* Germ., our American species is new.

The first bed of coal above the conglomerate, our No. 1A, is generally thin (two feet to four feet thick at the most), and overlaid by a stratum of coarse sandstone or of black very bituminous shales. In the shales, I have never found any other remains of plants, than leaves and cones of *Lepidodendron*, six species of *Lepidostrobus* and *Lepidophyllum*. The shales are too bituminous for good preservation of specimens. With the remains of plants, the shales generally contain a few specimens of *Lingula umbonata* Cox, a shell extremely abundant in the shales of No. 1B, and rarely represented by a very few individuals in the coal No. 2. Sometimes coal No. 1A and No. 1B become united together, being separated only by a thin parting of shales, but more generally there is between them a stratum of coarse sandstone, marked with numerous prints or casts of great vegetables of the coal, especially of *Lepidodendron obovatum* Sternb., *L. rimosum* Sternb., *L. rugosum* Sternb., *L. aculeatum* Sternb., *Sigillaria alternans* Ll. and Hutt., *S. reniformis* Brgt., *S. Brardii* Brgt., *S. lævigata* Brgt., *Sirigodendron pachyderma* Brgt., and some fruits, *Carpolithes* and *Trigonocarpon*. Other species, one *Caulopteris*, one *Megaphytum*, some *Calamites*, all rendered undeterminable by the coarse compound of the sandstone, have been seen in this stratum.

Coal 1B. Its horizon appears to mark the epoch of the highest development of the vegetation of the coal formation. Not only is this coal bed the most reliable of all, and consequently the most extensively worked, not only does it attain locally an enormous thickness, justly meriting the name which it bears in some parts of Pennsylvania, viz., the *Big Coal*, the *Mammoth vein*, &c.; but the shales which cover it and sometimes divide it into two, three, or more members, afford to the explorer the greatest amount of species, distributed among nearly all the genera of plants which belong to the coal formation.

The vegetation of coal No. 1B may be characterized: First, by the great number of fruits, found in the strata connected with it, either in the shale above or in the sandstone below. Indeed, nearly all the species of *Trigoncarpum*, *Cardiocarpum*, *Rhabdocarpos* and *Carpolithes* belong to it. Its second characteristic, is the great abundance of species of *Lepidodendron*. Eighteen species of this genus have been found in this bed of coal, and no new species have been, as yet, seen above it. A third character is the constant presence in the shales of our No. 1B of *Alethopteris Lonchitidis* Brgt. which apparently belongs exclusively to it. Generally speaking, the coal has the great forms of the section of the *Pecopterideæ*, viz. *Alethopteris* and *Callipteris*, and is mostly

deprived of the true *Pecopteris* or of the small forms of the order. *Alethopteris Serlii* Brgt., is met in its shales, but is very scarce; the species rather belongs to No. 3. It has *Alethopteris marginata* Brgt., not seen in any other horizon; also *Alethopteris lævis* Lsqx., probably peculiar to it, and *Alethopteris nervosa* Brgt., which ascends higher. Besides the genus *Pecopteris* Brgt., I cannot mention any species peculiar to this coal. *Pecopteris velutina* Lsqx., a fine species, which by its fructification would be referable to a separate genus, was found in its shales; but we have mentioned it also with the subconglomerate coal. *Pecopteris Miltoni* Brgt., or *P. polymorpha* Brgt. (probably the same) is a species found sometimes in its shales; but it is common in the whole thickness of the coal measures. *Pecopteris pennæformis* Brgt., *P. Sillimanni* Brgt., *P. plumosa* Brgt., *P. villosa* Brgt., are connected with it, but are found still higher in the measures. The fourth character of this coal is the great number of species of large *Sphenopterideæ* and of *Hymenophyllites* connected with it. *Sphenopteris latifolia* Brgt., *S. obtusiloba* Brgt., *S. glandulosa* Lsqx., *S. polyphylla* Ll. and Hutt., *S. Newberryi* Lsqx., *S. artemisiæfolia* Brgt., with *Hymenophyllites Hildrethi* Lsqx., and *H. spinosus* Göpp., have not been hitherto found except with this coal.

Of the genus *Odontopteris* Brgt., all the American species are connected with No. 1B, except *O. crenulata* Brgt., which first appears in the subconglomerate coal.

Among the *Sigillariæ*, it has as species peculiar to it, *Sigillaria stellata* Lsqx., *S. Serlii* Brgt., *S. tessellata* Brgt., *S. Brochanti* Brgt., *S. alveolaris* Brgt., *S. oculata* Brgt., *S. polita* Lsqx., *S. obovata* Lsqx., *S. alternans* Ll. and Hutt., *S. discoidea* Lsqx., and *S. catenulata* Ll. and Hutt.

By far the greatest number of specimens preserved in the shales of this coal belong to two species which we have seen already below the conglomerate, viz. the omnipresent *Neuropteris hirsuta* Lsqx., and *N. flexuosa* Brgt. Although these two species are so abundantly represented in our coal No. 1B, that sometimes their remains exclusively, fill the roof of some mines, other species of *Neuropteris* are scarcely found in connection with it. *Neuropteris tenuifolia* Brgt., and *N. smilacifolia* Sternb., belong to it; but both species are very scarce and closely related to *N. flexuosa* Brgt. The last especially may be considered as a variety of it. *Neuropteris lancifolia* Newb. is an undescribed species, found in the shales of this coal, perhaps only one of the numerous forms of *N. hirsuta* Lsqx.

Connected with this remarkable coal bed, we still find *Cordaites borassifolia* Ung., and *Dictyopteris obliqua* Bunby., locally distributed; *Whittleseya elegans* Newb., formerly described and found at one or two places only; species of *Asterophyllites*, *Annularia* and *Sphenophyllum*, but none of them peculiar to it, and species of *Calamites*, especially *C. Suckowii* Brgt., *C. Cistii*

Brgt., *C. nodosus* Brgt., *C. approximatus* Brgt., and *C. cannæformis* Brgt., some of which ascend higher in the coal measures. I never found in it any specimen referable to *Calamites pachyderma* Brgt., which M. Geinitz unites, I think incorrectly, to *C. cannæformis* Brgt. Its true place is within the sandstone of the Millstone grit. Thus also, from dissimilarity of distribution, I would admit with Mr. Brongniart *Calamites decoratus* Brgt., and *C. Suckowii* Brgt., as distinct species, though they are also united by M. Geinitz; the last belonging especially to this coal, the former to a higher bed, No. 3d.

It is perhaps useless to mention that *Stigmaria ficoides* Sternb., is also present with our coal 1B. It has not only penetrated by its leaves the fire clay which the coal overlies; but has filled the coal also by its remains:—moreover, contrary to the assertions of some authors that *Stigmaria*, being a root, is found only in the bottom fire clay of the coal strata,—it has mixed its remains in the shales of this bed, and even sent them into the sandstone by which they are overlaid, or sometimes replaced. Thus, in the absence of other remains, or until I had discovered them, the abundance of *Stigmaria ficoides* in the roof-shales has helped me to identify this coal in many places.

The roof shales of No. 1B coal are occasionally overlaid by a stratum of limestone or argillaceous shale, containing a great abundance of fossil shells. Locally also, and where this limestone is absent, its place is taken by a bed of coal, variable in thickness from one to four feet. As it is rarely formed, and sometimes in close proximity to No. 1B, I consider it still as a member of No. 1B; and it is accordingly ranked in my sections as No. 1C. Though it has no great value,* its combustible matter being a compound of half decomposed stems, mostly transformed into charcoal and rusted by oxyd of iron, it is worth mentioning as an evidence of conformity of composition of the shales and of the coal strata at the same geological horizon over a wide area. The shales of this bed, even the coal itself, appear like a compound of broken, heaped up stems of ferns and *Calamites*. Now, it is found with exactly the same appearance, either of shales or of coal, on the western limits of the eastern coal basin of Kentucky, near Greenupsburg; in Virginia, on the Tug river; and in the middle of the great Apalachian coal basin, near the mouth of Yellow creek, in the Ohio river, above Steubenville, Ohio.

Coal No. 2, is generally placed at about one hundred feet above No. 1B, and separated from it by various strata of shales and sandstone, and occasionally by the limestone mentioned before, or also by a cherty compound named Burrstone. Its roof-shales

* It is particularly well developed in the northern part of the coal basin of Illinois and Indiana where I have seen it lately from four to six feet thick of pretty good coal.

are coarse, micaceous, and generally barren of fossil remains; but it is separated into two by a shale parting, of from two to eighteen inches, which contains a great abundance of broken remains of plants. Here, we have scarcely any trace of *Lepidodendron*, but a remarkable abundance of *Calamites*, *Asterophyllites*, *Neuropteris flexuosa* Brgt., *Neuropteris hirsuta* Lsqx., *Cordaites borassifolia* Ung. I have found with this coal *Lepidodendron obovatum* Sternb., *Sigillaria Brardii* Brgt., with its leaves, and an undescribable *Lepidostrobus* Brgt. Without doubt, it has many peculiar species, but I have never found the shales hard enough for preserving specimens even of a moderate size. As soon as they are exposed to atmospheric influence, they are rapidly broken into minute particles by efflorescence of the sulphuret of iron, generally predominant in this coal. Its vegetation, as far as can be seen, is intermediate between No. 1B and No. 3d coal, the number of predominating species being from the genera *Asterophyllites*, *Annularia*, and especially *Calamites*.

Coal No. 3 is variable in thickness, and is not as generally and as uniformly formed as No. 1B. Wherever it has been seen it is overlaid by a roof of gray soft shales containing a great quantity of well preserved remains of plants. It has still a few species of *Lepidodendron: Lepidodendron dichotomum* Sternb., and especially its branches, are abundantly distributed in its shales, with a great number of its long cones, *Lepidostrobus variabilis* Brgt., and its leaves. *Dictyopteris obliqua* Bunb. is still found connected with it and locally distributed as in coal No. 1B. It has also in abundance *Neuropteris hirsuta* Lsqx., and *N. flexuosa* Brgt., and as peculiar species of this genus, apparently belonging exclusively to it, *Neuropteris Clarksoni* Lsqx., *N. gigantea* Sternb., *N. delicatula* Lsqx., and *N. rarinervis* Bunby. The genus *Sphenopteris* Brgt. is represented in this coal by *Sphenopteris flagellaris* Lsqx., *S. Lesquereuxii* Newb., and by an *Hymenophyllites*, intermediate between *H. elegans* Brgt., and *H. Hildrethi* Lsqx., and which is perhaps only a variety of the last species. The section of the large *Pecopterideæ* shows in it numerous remains of some of its species, especially *Alethopteris Serlii* Brgt., *A. nervosa* Brgt. and *A. muricata* Göpp. This last is uncommon and has been found only in connection with this coal. The species of true *Pecopteris* are more numerous than in coal 1B, beginning here to show their predominance. *Pecopteris unita* Brgt., *P. polymorpha* Brgt., *P. Loschii* Brgt., *P. Sillimani* Brgt. are connected with this bed, though none of them except perhaps the first is peculiar to it. *Asterophyllites*, *Annularia* and *Sphenophyllum* have left their remains in its shales, all still more abundant in No. 4 coal, except *Annularia sphenophylloides* Ung., which attains here its greatest development. Among the *Calamites*, it has *Calamites decoratus* Brgt., *C. undulatus* Brgt., the first apparently peculiar to it, with *C. cruciatus* Brgt. and *C. ramosus* in abundance. Thus

far, I have never found with this coal *C. Suckowii* Brgt., which has left so many of its remains in coal 1B. A few of the most common species of *Sigillaria*, viz. *S. Brardii* Brgt., *S. Menardi* Brgt., *S. reniformis* Brgt. and *S. Yardleyi* Lsqx., all species (except *S. Menardi* Brgt.,) which ascend higher or are found also in No. 1B. To this enumeration, I may add two species of fruits, *Carpolithes amygdaliformis* Göpp, and a small *Cardiocarpon*, fruit of an *Asterophyllites*. It is found also with No. 4th coal.

Coal No. 4th is the coal of the small ferns, especially of the small *Pecopterideæ*. It has no more remains of *Lepidodendron*, neither cones, nor leaves of this genus. Still it has some *Sigillariæ*. *Sigillaria lepidodendrifolia* Brgt., *S. Brardii* Brgt., *S. Defrancii* Brgt., *S. sculpta* Lsqx., *S. obliqua* Brgt.; *S. dilatata* Lsqx., *S. fissa* Lsqx., *S. Schimperi* Lsqx. These five last species are peculiar to it. All belong to the sections of the uncostate *Sigillariæ*. Among the costate species, none have been found in the shales but *S. lævigata* Brgt. The remains of *Asterophyllites* and its cones, of *Sphenophyllum* and especially of *Pinnularia capillacea* Ll. and H., are extremely numerous in its shales. This last species scatters its threadlike branches in every direction and mixed with *Neuropteris hirsuta* Lsqx.; and *N. flexuosa* Brgt. still common species of this coal, covers the roof of the Pomeroy vein with a painting of beautiful garlands. *Dictyopteris obliqua* Bunby., still appears with this coal, but is very scarce indeed, a species apparently dying out. Now the *Neuropterideæ* become more predominant and varied than in any other horizon. Thus, *Neuropteris speciosa* Lsqx., the most beautiful of the genus, *N. fissa* Lsqx., *N. plicata* Sternb., *N. rotundifolia* Brgt., *N. Grangeri* Brgt., *N. Cistii* Brgt., *N. Villersii* Brgt., *N. gibbosa* Lsqx., *N. undans* Lsqx., *N. tenuinervis* Lsqx., *N. dentata* Lsqx., *N. Desorii* Lsqx., *N. heterophylla* Brgt., all these species, except perhaps the last, appear for the first time, and are probably contemporaneous with this coal only. It has still *Neuropteris crenulata* Brgt., a species connected also with No. 1B. The *Sphenopterideæ* are represented here by *Sphenopteris tenella?* Brgt. (The only specimen found was indistinct.) *S. Gravenhorstii* Brgt., *S. Dubuissonis* Brgt., *S. abbreviata* Lsqx., *S. intermedia* Lsqx., *S. plicata* Lsqx., all species of the same type with small dissected leaflets, far different from the characteristic type (the large leaflets) of the species of No. 1B. To this coal belong exclusively all the species of doubtful affinity, referred by some authors to *Aphlebia* Sternb., and connected in my catalogue with *Hymenophyllites* Göpp., viz. *Hymenophyllites fimbriatus* Lsqx., *H. affinis* Lsqx., *H. hirsutus* Lsqx. and *H. giganteus* Lsqx.

The *Pecopterideæ* have the first rank for the number of representatives in coal No. 4th. It has *Alethopteris Pennsylvanica* Lsqx., *A. aquilina* Brgt., *A. urophylla?* Brgt., (specimens incomplete,)

A. obscura Lsqx., *A. serrula* Lsqx., *A. rugosa* Lsqx., with *Pecopteris arborescens* Brgt. (abounding), *P. notata* Lsqx., *P. distans* Lsqx., *P. oreopteridius* Brgt., *P. pusilla* Lsqx., *P. dubia* Lsqx., (referable with doubt to *P. arborescens* Brgt.,) *P. cyathœa* Brgt., *P. arguta* Brgt., *P. concinna* Lsqx., *P. incompleta* Lsqx., mostly species peculiar to this coal. *Pecopteris polymorpha* Brgt. is also found in its shales.

The genus *Calamites* is here represented by *Calamites cruciatus* Brgt, *C. dubius* Brgt., *C. bistriatus* Lsqx., *C. disjunctus* Lsqx. These two last species have been found only with this coal; but each has been established on single specimens and thus they are still uncertain.

From this enumeration, it is evident that we have passed at this geological horizon to a vegetation much reduced in the size of its representatives and of a quite different character. The arborescent species belong to the ferns, or to *Sigillaria*, of small size.

Our 4th coal is covered, as was said before, by a thick stratum of sandstone, generally conglomerate in part, varying in thickness from 10 to 150 feet. The vegetable fossil remains of this sandstone afford a new evidence of the predominance of the ferns at this geological horizon, and of the disappearance of *Lepidodendron*. It is the immediate deposit of silicified trunks of *Psaronius*, extending from Ohio to Virginia along the Great Kanawha river. At Shade river, near Athens, Ohio, the broken pieces of these trees are so numerous that they cover in places the bed of the creek.* They appear generally as pieces of small stems horizontally broken, varying from two to eleven inches in thickness. The largest specimen which I was able to find is apparently the base of a tree. It is nearly round, eleven inches in diameter, and perforated, not in its central part, but somewhat on one side, by a regular round hole four inches in diameter. Many of the small specimens have their surface regularly costate like species of *Sigillaria;* but their internal structure is apparently that of *Psaronius*. It would be very interesting to compare with ours the position of the *Psaronius* deposit of Europe, which, I suppose, is contemporaneous.

The five hundred feet of measures intervening between the Mahoning sandstone and the great Pittsburg coal, have not afforded hitherto very abundant materials for the study of their botanical remains. It has been seen already that, in Pennsylvania, this space is occupied by strata of shales, sandstone and limestone which are generally barren of coal, at least of

* Unhappily, I have not as yet been able to obtain for microscopical examination polished lamellæ of sections of the collected species and cannot give an exact account of them. But the work of preparing the specimens is now in progress, and the view of internal structure of those interesting remains will soon afford the possibility of determining the species.

any bed of coal of sufficient thickness to encourage the working. Thus the shales are still unopened and no chance is given of examining them. In Kentucky where in the same space the coal is more developed and has been opened at different places and different geological horizons, the shales roofing the coal-strata are mostly very bituminous and contain especially animal remains, fishes and shells, either with or without few fossil plants. Nevertheless I have been able to find here and there some determinable species affording points of comparison for the distribution of the coal-plants in those higher measures. Thus, the fire-clay of the bottoms of all the coal-strata is always filled with remains (leaves only) of *Stigmaria ficoides* Brgt., and at any place where the coal is formed, it shows on its horizontal sections the carbonized prints of *Calamites*, *Pecopteris* and *Stigmaria*.

Coal No. 6 is covered by a schistose, gray, laminated sandstone, blackened by broken fragments of ferns. Leaflets of *Pecopteris*, *Sphenophyllum*, *Asterophyllites* and crushed branches of *Calamites*, are distinguishable in great abundance among the fragments; but their specific determination is not possible.

Coal No. 8, has in its shales *Pecopteris polymorpha* Brgt. in abundance. Near Marietta, Ohio, its place is occupied by a red soft shale full of the remains of *Asplenites rubra* Lsqx., closely related to *Pecopteris arborescens*. *Neuropteris hirsuta* is there also in its normal form.

Coal No. 9. Its roof shales contain mixed together a great quantity of well-preserved fossil shells, of scales and teeth of fishes, and of remains of ferns evidently floated. Two species of *Sphenopteris*, one of which appears identical with *S. gravenhorstii* Brgt., *Pecopteris polymorpha* Brgt., another *Pecopteris* referable by the small fragments found, to *P. arborescens* Brgt.; *Neuropteris flexuosa* Brgt., leaflets only separated from the stem, a few undeterminable species of *Calamites* and one *Sigillaria*.

Coal No. 11. The great Pittsburg coal has also both animal and vegetable remains, but generally on isolated strata among the shales. At Pittsburg the lower bed is roofed by black bituminous shales which appear formed wholly by remains of stems of *Neuropteris hirsuta* Lsqx. and by leaves of *Cordaites borassifolia*, and in the shales of the upper part of this coal, which corresponds to our No. 12 and which in Kentucky is sometimes separated from No. 11 by a thin and very irregular bed of limestone, there are at Pittsburg well preserved specimens also of *Neuropteris hirsuta* Brgt., *N. flexuosa* Brgt., *Pecopteris polymorpha* Brgt., *P. arborescens* Brgt., *P. cyathæa* Brgt., *Sphenophyllum emarginatum* Brgt., three species of *Calamites* and one *Sigillaria*. The same species with a far greater proportion of *Calamites* and also one

*Sigillaria** are found at Paradise, on Green river, Kentucky, in the shaly or 'brashy' coal separating No. 12th coal from an iron blackband which overlies it. I must not omit to mention with this coal the first appearance of a species somewhat related by its form to the species of the Oolitic series. It is the remarkable *Neuropteris Moorii* Lsqx., which by its pointed leaves and alate primary or secondary rachis, is distinct from any typical form of the coal-plants. It may be compared by its general appearance to *Alethopteris Whitbiensis* Brgt. of the Oolite of England but the affinity is distant indeed, as the American species has no marked medial nerve and some of the forked and arched nervules of its leaflets emerge from the common rachis.

The third great sandstone formation, or the Anvil-rock sandstone, which underlies the highest section of the coal-measures, is from all appearance as distinct a point of division in the distribution of the fossil flora as any one of the other great sandstones, the conglomerate and the Mahoning. From my own observations and from the data collected by other geologists, especially by my friend J. P. Lesley, no trace of *Lepidodendron* appears either in the Anvil-rock sandstone or in the measures above it. At least, none has been found as yet. This sandstone nevertheless is not barren of fossil vegetables. Near Greensburg, Penn., it contains in abundance, petrified trunks half silicified, half transformed into sandstone. Among the specimens which I had an opportunity to examine in the cabinet of Prof. Moore, I found a portion of the base of a small tree which had been evidently imbedded in the sandstone, in its standing position, still preserving the embranchment of three diverging roots. The surface of the tree and of the roots is marked by peculiar scars. Though not perfectly distinct, it was at once evident that this fossil tree did not belong to any of the genera of plants before seen in the coal. It was nevertheless impossible to describe it, in its state of obliteration. Later, Dr. D. Dale Owen, the celebrated geologist of New Harmony, discovered in the Anvil-rock sandstone of Posey Co., Indiana, not far from the Wabash river, three or four standing stumps which by examination proved to belong to the same species of trees as the one found at Greensburg. The specimens of Dr. Owen have been carefully removed and are preserved in his cabinet, with the roots attached to them, just as they were found. The stem is round, about one foot thick, branching at its base in five or six large roots, diverging nearly horizontally. Its surface is narrowly reticulated, and is marked by double oval scars, united by a deep wrinkle, very regular in their position, and about one inch distant from

* It is a costate species which appears to be the same at No. 9th and No. 12th coal. All the specimens have lost the bark and I could never find the scars except those which were too much obliterated for satisfactory determination.

each other. At the point where the roots branch and diverge from the trunk, the double scars become more and more separate, more irregularly placed, and thus the roots take somewhat of the appearance of *Stigmaria*. The difference is well marked, nevertheless; the scars being triangular, marked in the center by a deep point only, and the roots quickly diminishing in size and terminating in a point at a short distance from the base of the tree. The imbedding shales not having been preserved, there is no trace of rootlets. Thus we have here, at this high position in the coal measures, a new typical form which probably indicates a difference of vegetation in the subsequent and last stage of the coal formations.

This enumeration is already too long, and though still incomplete, it must be abruptly closed, for fear of becoming tedious to the reader. In order to be understood by those who are not acquainted with botanical palæontology, it is only necessary to sum up and briefly discuss some of the conclusions which are derived from this examination.

Considering its generic distribution, the American coal-flora is nearly related to the European. We have only two or three peculiar genera, representing distinct types, which have not been seen in Europe. On the contrary, Europe has no peculiar and true generic types of coal-plants which are not represented in the coal-fields of the United States.

Considering its species, a more marked difference in the coal-flora of both continents becomes evident. Some of our species represent marked and peculiar forms or types, which are not seen in Europe, though a much greater number of species has been found in its coal-measures. Thus the predominance of typical or distinctly characterized forms, belongs to our country. By comparison of the flora of our epoch on both continents, we find now the same proportional relation and difference as at the time of the coal formation, that is, on this side of the Atlantic a predominance of well marked types; a predominance of species of trees;* a number of species perfectly identical on both continents, and many American species so nearly related to European congeners that their specific characters can hardly be established.

Though further researches ought necessarily to increase the number of species of fossil plants belonging to our coal measures, the proportional difference is likely to remain as it is established above.

The fossil-flora appears identical at the same geological horizon, over the whole extent of our coal-fields. This proves uniformity of stratification and geological unity of the different coal basins of America.

* The distribution of the genus *Lepidodendron*, at the time of the formation of the coal, has some analogy with that of the Oak in our time.

The first trace of vegetable terrestrial life appears in the middle of the Devonian in a species of *Lepidodendron*, represented by its bark, its leaves, its cones, and large trunks of silicified wood. No remains of any other form of terrestrial vegetation have been seen in strata either inferior or cotemporaneous to this. All the vegetable remains known in the Silurian and lower Devonian belong to species of fucoides or marine plants, mostly of small size, resembling some species of *Fucus* of our time. The first leafy terrestrial plants appear in the Old Red sandstone. All the representatives of this new vegetation belong to a peculiar genus, *Noggerathia* Göpp., more related to Conifers or even to Palms than to Ferns. They are found in the same geological horizon, both in Europe and in America, and entirely disappear at or before the beginning of the coal epoch.

Ascending to the base of the coal-measures, we find there simultaneously in the subcarboniferous sandstone and below the upper Archimedes limestone different species of trees of large size. At the base of the Millstone-grit, where the coal begins to be formed, the number of species of large sized trees, especially of *Lepidodendron*, increases. At the same time, we see here the first species of ferns belonging to the true coal-measures, and already some species which reappear periodically with each bed of coal, in the whole thickness of the coal-measures.

At coal No. 1B, the second above the Millstone-grit, we have apparently the maximum of predominance of species of large size, especially of *Lepidodendron*. From this horizon upwards, *Megaphytum*, *Ulodendron*, *Halonia*, *Caulopteris*, *Lomatophloios* and *Knorria* are not seen any more. The species of *Lepidodendron* diminish in number to coal No. 4, where they are entirely lost; at least they have not been found as yet in any strata of the coal-measures above it. The genus *Sigillaria* follows also from coal 1B the same gradual diminution in the number of its species; but it is preserved in one or two representatives as high as coal No. 12.

As fast as these species of trees decrease in number, the ferns mostly of small size invade the coal-fields. They become predominant and show the greatest number of species at the base of the Mahoning sandstone.

This substitution of species is not the result of any perceptible change in their character or in their relative affinity. The relation of *Lepidodendron* is to *Lycopodites*. Both genera appear or at least disappear at the same time, and are replaced by typical forms, which have no analogy whatever with them.

The distribution of the ferns in the coal-measures is equally contrary to the supposition of a change of species by successive variations. They appear, it is true, grouped together, in a kind of relation between contemporaneous species; but we do not see, either before or after any of them, a trace of an intermediate

form between the lost types and the following ones. The large-leafed *Sphenopterideæ*, the *Odontopterideæ* belong to coal No. 1B with most of the fruits of the coal measures; the *Neuropterideæ*, the *Pecopterideæ* and a peculiar section of small leafed *Sphenopterideæ* belong to coals No. 3 and 4.

As if to show how useless it would be to argue on the distribution of the coal-flora as resulting from successive variations of species and of genera, we find predominant genera represented in the whole thickness and in the whole extent of the coal-fields by species so variable that they can be called polymorphous, and which nevertheless preserve everywhere their identity. Thus appear *Neuropteris hirsuta* Lsqx., *N. flexuosa* Brgt., *Pecopteris polymorpha* Brgt. In the palæontological report of the Pennsylvania geological survey, I have figured eighteen forms of the first of these species, passing by insensible transitions from a small round leaflet to a large, nearly square *Cyclopteris;* then to cordate or reniform leaf of medium size; then to opposite, oval-lanceolate leaflets united by a narrow margin; then to a digitate leaf of which the five divisions are lanceolate-obtuse, and thus *ad infinitum*. Nevertheless, this species is perfectly well characterized and may be identified at first sight in any of its multiple forms.*

There is not in the number of *Neuropterideæ* and *Pecopterideæ* a well characterized species which could be admitted as a modified form of the predominant and variable species. Moreover, the numerous species of *Neuropteris* and *Pecopteris* appear at coal No. 3 and 4 in the middle of the coal-measures, and do not ascend higher, while those species which should be considered as originators or parents and consequently ought to be destroyed (from the law of selection) by their offspring, continue to predominate to the top of the coal-measures. Thus the vegetation of the coal shows at different geological horizons, both a gradual and sudden disappearance of species and even of types; both a gradual and sudden appearance of other species or of peculiar types, without regard to the former or extinct ones, and a continual reappearance in the whole thickness of the coal-measures of well-established species which neither by their form or their nature appear particularly prepared to sustain without varying the successive changes which have acted on the surface of the coal-measures at the time of their formation.

It is certainly possible to suppose that some disturbance, immersion, or upheaval of the coal-marshes, has modified their

* As the specimens are mostly found in simple leaflets detached from the stem, and consequently the species cannot be identified in its varieties by the examination of a stem bearing leaves of different forms, this facility of identifying any single leaflet may answer the reproach made to palæontological Botany, that it is a science directing its researches to variable parts of beings of which the true nature and real form is generally unknown, and that consequently its conclusions are more or less problematic. This reproach was long since conclusively answered in a letter of Prof. Heer to Sir Charles Lyell.

vegetation. But this supposition would not explain how it happened that the most obvious changes in the vegetation of the coal have not followed the formation of those great strata of sandstone, which, like the Millstone-grit or the Mahoning sandstone, must have employed a longer time than any other stratum for the gathering up of their materials.

The supposition may be further extended, and it may be asserted that the disappearance of certain types, or of vegetables of a large size, from the marshes of the coal-fields is only apparent. That in their forced migrations by the gradual submersion of the marshes, some species have been either arrested somewhere, and thus left inhabiting other countries or destroyed for a time by a too slow migrating process, while others, having the faculty of migrating developed in a larger degree, have reappeared again and again on the marshes, living there for a longer period.

The field of supposition is unbounded, but it is a field where science is not permitted to wander. Where have the new types or species come from? How is it, if the disappearance of vegetables like *Lepidodendron* is only apparent, or local, that we do not find any of their remains succeeding the carboniferous epoch.* And admitting that species of *Lepidodendron* have been arrested in their migrations on some dry land, should we not find above our 4th coal some remains of this genus in the strata of sandstone where so many trunks of *Psaronius* have been imbedded.

I wish that I had time to discuss here at length and with the attention which it merits, a subject of importance connected with the examition of the stratigraphical distribution of the plants of the coal-epoch. Are the coal-measures a single, unique formation? Do they belong to a single epoch, or are they composed of a succession of formations separated by immense space of time, and of which the different stages might be compared to those of the recent formations: the Eocene, the Miocene, and the Pliocene, for example? In the last case, can we admit the vegetation of which the remains have been preserved in the shales of the coal, or the vegetation of the coal-marshes, as a true representative of the flora of the various epochs where the coal was formed; or was it then, as the bog vegetation is at our time, composed of a peculiar group of plants, adapted to the formation of the coal, pertaining to the marshes only, while another

* A single specimen of *Stigmaria* is said to have been found in Germany in the Todtliegende or Permian. But the locality has not been ascertained and consequently the statement cannot be relied upon. Moreover for a long time and in many places, as I have seen it myself, the Permian in Germany was taken for the Old Red sandstone and vice-versa, from the difficulty of ascertaining its position and from the want of fossil remains. I cannot take into account as contradicting my assertion, one *Lepidodendron* mentioned by Mr. Murchison as found in the Permian of Russia.

flora of a different character was covering the dry land, if there was any dry land, at the carboniferous epoch?

From the thickness of some beds of coal, representing a mass of combustible matter as great at least as that which is contained in our oldest and deepest peat bogs; from the thickness and various composition of the strata which separate the beds of coal, and from the successive changes in the vegetation of the coal, it appears that the last alternative is admissible. Different hypotheses have been put forward to explain the so-called huge or gigantic vegetation of the coal-formations. But there is nothing in the carboniferous epoch authorizing the supposition that the power of vegetable life was greater than it is at our time. The combustible matter heaped in some of our peat bogs is sometimes sufficiently thick to be equivalent to the coal of a bed of four to five feet. The trees growing in our marshes or on the peat bogs are generally larger than those which have been preserved in the strata of the carboniferous measures. The Dismal Swamp is impenetrable on account of the great compactness of its vegetation. It is not an easy matter either, to get across the heaped, half prostrated or erect and closely pressed trees of our cedar-swamps of the North. If such marshes were extended over the greatest part of the United States, they would present a fair representation of those of the carboniferous period.

The occasional appearance of petrified trees, standing imbedded in sandstone, does not give evidence of a rapid formation either of the coal or of the other strata. Local disturbances may throw a few feet of sand upon a marsh, covered with active vegetation, and thus preserve the stumps from decomposition and by-and-by these may be converted to stone. The bald cypress and other species of trees grow sometimes in the marshes near the sea shore under ten feet of water. Whole forests of those trees have been imbedded in a standing position in the marshes around New Orleans. Thus I do not find in the geological records of the carboniferous period any indication of a rapid process of formation, either cataclysmic or abnormal, and I readily admit that each bed of coal with its accompanying strata of fire-clay and shales has required for its formation a period of time as long as any of our recent geological divisions.*

The question concerning the existence or non-existence of dry land covered with a peculiar vegetation at the epoch of the coal formation, cannot be answered positively or negatively by sufficient evidence. The only fact that would indicate that the

* Thus, if a peculiar nomenclature for a classification of the different strata of the old red sandstone, of the subconglomerate coal, and of the Millstone-grit is admissible, the process of division should be extended to each bed of the coal-measures.

marshes of the carboniferous epoch were surrounded by land-bearing plants of different kind than those living on the bogs is the presence in coal No. 1B and in the sandstone underlying it of a great number of fruits of different species which by their nature have no relation to any of the other remains preserved in the coal. They have been generally referred to species of *Cordaites*. But the two only species of our coal measures are found in abundance at geological horizons where the fruits are entirely absent. And even at coal No. 1B shales appearing entirely composed of heaped remains of leaves of *Cordaites borassifolia* do not contain any fruit. The species of fruit, *Carpolithes Cordai* Gein., referred by M. Geinitz to *Cordaites borassifolia, our most common and omnipresent species*, has not been found in the coal measures of America. Therefore, either the fruits of unknown relation, *Carpolithes*, *Trigonocarpa* and *Rhabdocarpos** belong to vegetable species which have grown on the marshes, and of which the remains, leaves and stems, have been entirely obliterated or those fruits belong to species growing out of the marshes, around them, and have been floated and thus disseminated in the shales and in the sandstones. This last opinion appears at first confirmed by a similar process of distribution of species in our deep swamps. I have already mentioned elsewhere† how the hollow trunks of the bald cypress which grows in Drummond lake (Dismal Swamp of Virginia) are filled by fruits, acorns, nuts, &c., of trees which grow on the dry land near its borders. But, it is not presumable that species of fruits only could have been floated and disseminated by the agency of water without any of the branches and of the leaves of the plants to which they belong. And nowhere have the shales, covering what is called the tail of a coal bank, viz: the part abutting against a hill of sand or losing itself in sandstone, exposed any remains of plants of another type than those belonging to the true coal formation. Even where the shales of the coal are covered with remains of shells and of fishes, and consequently formed when the marshes were immersed, all the floated remains of plants which are found with those of animals belong to the common species of the coal. I believe then that the plants preserved in the shales of the coal give us a fair representation of the general flora of the carboniferous epoch, as true and as general at least as the fossil plants of the miocene represent the general flora of the tertiary period. And I suppose that if there was any dry land around the marshes, the vegetation contained only a few species different from those living on the marshes. But this last opinion is merely hypothetical.

[*To be continued.*]

* I consider the *Cardiocarpa* as the fruits of Asterophyllites and probably of some species of Calamites.

† Introduction to the fossil flora of Pennsylvania, Geol. Rep. of Penn., p. 847.

ART. XXXIV.—*Additional observations on the Circulation in the Eye;* by OGDEN N. ROOD, of Troy University, N. Y.

IN a notice which appeared in the September number of this Journal, I described a subjective phenomenon, which is seen when a bright sky is viewed through two or three plates of cobalt glass. Most persons who are in the habit of directing their attention to this class of phenomena, have even perceived *faint indications* of the circulatory movement with the naked eye. But in the experiment with the cobalt glass, where this motion is seen with distinctness, as well as in the faint indications of it obtained with the unassisted eye, the moving bodies are not observed to be in compact masses, but as it were, sprinkled over the field of view.

If however the light of a spirit-lamp with a salted wick, be concentrated on the eye by means of a convex lens, 3 inches in diameter, having a focal length of about 3 inches, the bright field soon resolves itself into a mass of small, round, *densely packed* moving bodies, which appear light on a dark ground.

This is seen with varying degrees of readiness by different persons: some perceiving it in a few seconds, others requiring a protracted gaze of several minutes.

The moving bodies at first appear very closely packed together like fine mosaic-work, but as the view grows more distinct, their path can be traced, and the conviction is forced on the mind of the observer, that they are moving at slow uniform rates, through narrow channels; the whole reminding one strongly of the circulation seen in the web of a frog's foot, by a microscope slightly out of focus.

The interposition of plates of yellow glass rather adds to the distinctness of this appearance.

The indistinct vision attendant on faintness or on mere eye-weariness, is, I suspect, in many cases, mediately caused by the appearance of this circulation: for example, some weeks ago, I tried the experiment of binding up the right eye, and using only the left, for two days. After reading with left eye for half an hour, the page grew indistinct, the letters apparently dissolved and this dense circulation, which I had previously observed, set in, and continued to be visible for some minutes. It reappeared a number of times during that, and the following day.

Subjoined is an extract of a letter from Prof. Wm. B. Rogers.

"Your experiment with the blue glass appears to render much more *distinctly visible* a phenomenon which I have often observed and which has been noticed by others. After a continued effort of vision in experiments on binocular combination or in the use

of the microscope as well as after active exercise, or any other stimulus to the circulation, I am able to reproduce it easily and with great clearness.

"When in these conditions I look intently with the naked eye upon a bright surface as that of a white cloud or a sheet of letter paper in the sunlight, the first appearance presented is that of numerous bright points darting around in various broken curves, coming in view and disappearing fitfully, but in such positions as to indicate the recurrence of the same motions, or the passage of successive particles in certain prescribed and permanent channels.

"As the eyes continue to be fixed on the surface, a shade comes over it, and on the dark ground I see innumerable streams of particles, moving in infinitely various loops and other curves, which, by a little attention, are observed to maintain a constant pattern, strikingly analogous to the capillary circulation as seen in the microscope. These streams of particles are of a tawny yellow tint well contrasted with the dark brownish surface in which they appear.

"Under the most favorable conditions of the organ I can usually obtain the effect with both eyes open, but it is more certain and far more distinct with a single eye, the other being closed. I should add that the appearance rarely lasts more than one or two seconds at a time, being obliterated by the recurrence of the white illumination and after a short interval returning, though usually with less distinctness than when first seen.

"In looking through a tube of black paper at a white surface until the eye has become fatigued, and we should perhaps add *greatly excited*, I have often noticed the same phenomenon and I believe I could at any time bring into view the yellowish mass of the circulation by continuing the experiment for a minute or two. With the lens of my pocket microscope held at about the focal distance I scarcely ever fail to obtain this effect in a few seconds.

"Your experiment with the blue glass is very interesting and succeeds with me perfectly. It will be a great gain if with comparatively little discomfort and without risk we shall be able to scrutinize steadily this intraocular phenomenon."

ART. XXXV.—*Some experiments and inferences in regard to Binocular Vision*; by Prof. WILLIAM B. ROGERS.

IN the theory of binocular vision which has been so ably expounded by Sir David Brewster, Brücke, and others, it is contended that no part of an object is seen single and distinctly but that to which the optic axes are for the moment directed, and that "the unity of the perception is obtained by the rapid survey which the eyes take of every part of the object." According to this view our perception of an object in its solidity and relief, instead of being the simple and direct result of the pictures formed at any one moment in the two eyes, is acquired by a cumulative process, in which the optic axes are successively converged upon every point of the object within view.

In an experimental discussion of some points in binocular vision published in the Am. Journ. of Science several years ago,* I was led to conclude that the phenomena of the stereoscopic resultant do not necessarily or even usually conform to these conditions, and that "the perception of a perspective resultant line or of a physical line in the same attitude does not require the successive convergence of the axes to *every point*." The grounds of this conclusion were,—first that the perspectiveness of the resultant although not perceived when the axes are steadily maintained at any one convergence, appears as soon as they are allowed sufficient freedom of motion *to unite a few contiguous points* of the component lines, and that it then effects the whole extent of the resultant; and—second that the resultant presents a perspective attitude even when the component lines, instead of being united into one, are brought together so as to intersect at a small angle, *each of the intersecting lines in this case appearing in relief.*

Satisfied from these considerations that the perceived singleness and relief of the resultant are to be ascribed rather to a *process of suggestion* then to the exhaustive binocular survey which has been supposed necessary, I was led to the opinion that, while some change of direction and convergence of the axes is needed for the effect, the successive view of a few contiguous points is all that is required to bring the suggestive action into play and to give rise to the full perception of the position and relief of the resultant.

In this view while rejecting the theory of successive vision in the form in which it has been propounded, I still considered some degree of motion of the axes as one of the steps by which we obtain the perception of the binocular resultant.

The following experiments, intended still further to test the theory of the successive combination of corresponding points

* This Journal, [2], xx, 86, 204, 318, and xxi, 80, 173, 439.

in binocular vision, are believed to be in part new, and are in part modified repetitions of experiments already described by Profs. Wheatstone and Dove. They offer what seems to be decisive proof that such a successive combination of pictures point by point, however it may enter in many cases into the complex process of vision, *cannot be regarded as an essential condition to the singleness and perspectiveness of the binocular perception.*

1. Let a brilliant line, held in a perspective position at a convenient distance midway between the eyes, be regarded intently for a few seconds so as to produce a lasting impression on the retinæ. On turning the eyes towards a blank wall or screen the subjective impression will be seen projected against it and having the same perspective altitude as the original line. If then one eye be closed the line will appear to subside into the surface of the screen taking an inclined position corresponding to the optical projection of the original line as seen by the unclosed eye and therefore corresponding to the image formed in that eye. By opening and closing the eyes alternately, and finally directing both to the screen we are able to see the two oblique lines corresponding to these projections and their binocular resultant corresponding to the original object.

2. Let two slightly inclined luminous lines formed by narrow slits in a strip of black card-board be combined into a perspective resultant either with or without a stereoscope. Looking at this for a few seconds so as to induce the reverse ocular spectrum, and then directing the eyes towards the opposite wall of the apartment, *a single spectrum will be observed having the attitude and relief of the original binocular resultant.*

As a strong illumination of the lines is necessary to bring out the most striking effect, the card-board should be held between the eyes and some brilliantly white surface, as the globe of a solar lamp or a strongly illuminated cloud, care being taken to prevent the entrance of extraneous light.

3. Using the same arrangement, let the luminous lines be regarded in succession each by the corresponding eye, the other eye being shaded so that no direct binocular combination can be formed. On looking toward the wall it will be seen that *the two subjective images unite to form a single spectral line having the same relief as if the lines had been directly combined* with or without the stereoscope.

While the perspective image continues distinctly visible, let either eye be closed the other being still directed towards the wall. The image will instantly lose its relief and take its position on the plane of the wall as an inclined line corresponding to the subjective image in the eye which has remained open. When the subjective impressions have been sufficiently strong, it is easy to alternate these effects by projecting first the picture

proper to the right eye and then that of the left on the plane of the wall, with their respective contrary inclinations. On then looking with both eyes we see the resultant image instantly start forth in its perspective altitude.

It is hardly necessary to say that in order to obtain these effects satisfactorily even with lines very strongly illuminated, the observer should have some practice in experiments on subjective vision. *In these circumstances, however, I have found the results to be perfectly certain and uniform.*

The conditions of the experiments are obviously such as to exclude all opportunity of *a shifting of the image on the retina.* Such a shifting however is essential to that successive combination of pairs of points in the two images which on the theory of Brewster is required for the production of the single perspective resultant. Hence according to this theory the resultant spectrum in these experiments, instead of being a single line in a perspective position, ought to present the form of two lines inclined or crossing, situated in the plane of the wall without projection or relief.

In reference to the first two experiments it might perhaps be maintained that as the perspectiveness of the original line or resultant on which the eyes were converged formed part of the direct perception in the first stage of the experiment, it would be likely through association to be included also in the spectral or subjective perception. But this consideration, which at best does not impress me as of much weight, is entirely inapplicable to the conditions of the last experiment, where the eyes are in the first place impressed *in succession* with their respective images, and where yet when they are together directed to the wall, *the perspective single resultant at once springs into view.*

4. Without resorting to these troublesome efforts of subjective vision the following is a simple proof that pictures *successively* impressed on the respective eyes are sufficient for the stereoscopic effect. Let a screen be made to vibrate or revolve somewhat rapidly between the eyes and the twin pictures of a stereoscope, so as alternately to expose and cover each, *completely excluding the simultaneous vision of the two.* The stereoscopic relief will be as apparent in these conditions as when the moving screen is withdrawn.

Here there is no opportunity for the combination of pairs of corresponding points in the two diagrams by the simultaneous convergence of the optic axes through them, but at each moment the actual picture in the one eye, and the retained impression in the other, form the elements of the perspective resultant which we perceive.

5. The ingenious experiments described by Prof. Dove many years ago in which the stereoscopic effect was obtained by the

momentary illumination of the electric flash, furnish a further and most powerful argument against the theory of successive binocular combination here referred to.

In repeating these I have found great advantage in using one of Ritchie's improved Ruhmkorff coils having a coated jar included in the outer circuit, the intensely brilliant spark of which can be made to throw its light upon the object viewed in any direction or at any interval that may be desired.

When a twin-diagram of any simple geometrical solid was placed in the stereoscope and viewed by this momentary light it was found to exhibit the perspective resultant in most cases with a single spark, and it never failed to present it in perfection with a succession of sparks even when they followed each other slowly.

A large circular disc of brass, marked with the usual concentric striæ, was placed in a position to catch the illumination and produce the peculiar intersecting lines of reflected light. At each spark the bright resultant line due to the binocular union of these intersecting lines was seen penetrating the disc and extending in a steep angle beyond and in front of it.

As, according to Wheatstone, the duration of an electric spark is less than one-millionth of a second, it can hardly be supposed that in either of these experiments the eyes have time to make the successive changes of direction required, by the theory, for the singleness and relief of the observed resultant. Not less at variance with this theory is the familiar fact that the illumination of a single flash of lightning is sufficient to give us a clear perception of the forms and positions of objects to which the eyes are for the moment directed. So the long straight spark of one of Geissler's narrow vacuum tubes, glowing for an instant in a dark room, impresses a precise perception of the altitude and place of the tube and its included line of light, and even their regular path of the long spark through the air produces a distinct perception single and faithful to its devious directions.

We may therefore conclude—*first*, that the perception of an object in its proper relief, or that of the perspective resultant through binocular combination in a stereoscope, or otherwise, may and most usually does arise, by *direct suggestion* from the two pictures impressed, without requiring the successive combination of corresponding points;—*and second*, that for the singleness of the resultant perception, it is not necessary that the images should fall on what are called corresponding parts of the two retinas.

The condition of single vision in such cases seems to be simply this, that the pictures in the two eyes shall be such and so placed as to be identical with the pictures which the real object would make at a given distance and in a given altitude before the eyes.

XXXVI.—*Geographical Notices.* No. XIV.

PROF. GUYOT'S MEASUREMENTS OF THE ALLEGHANY SYSTEM.—It is well known to the scientific men of this country that Professor Arnold Guyot of Princeton, New Jersey, has devoted a portion of his summer vacations for ten years past to the study of the different portions of the great Alleghany system which faces the Atlantic coast from Canada to Georgia. Several years ago he measured the highest peaks of the Adirondack, Green and White mountains, in the northern part of the chain, and more recently he has been at work on the southern portion of the system which is found to possess the most elevated peaks of the whole Appalachian chain. His determination of some of the highest peaks of the Black mountains of North Carolina was published in this Journal, for September, 1857.

By a private letter from Professor Guyot we learn that during last summer (1860) he has devoted two full months to further measurements in the south, in company with Messrs. Sandoz and Grand Pierre. The weather has been propitious and he has accomplished much work, having measured between one hundred and fifty and two hundred points in addition to those which were previously determined. He has extended his investigations as far as Georgia, and has seen the extremity of the Blue Ridge and the Unaka. It may now be affirmed with safety that the southern portion of the Alleghanies is better known so far as pertains to its hypsometry, than any other portion of the system. There is reason to hope that at an early day Professor Guyot will lay before the readers of this Journal, in detail, the results of his important and prolonged investigations; meanwhile the reader will be interested in the following partial summary of his observations in North Carolina.

These measurements sufficiently indicate the grand traits of structure of that loftiest portion of the Appalachian system. It may be seen that the Roan and Grand Father mountains are the two great pillars on both sides of the Northgate to the high mountain region of North Carolina, which extend between the two chains of the Blue Ridge on the east and the Iron and Smoky and Unaka mountains on the west. That gate is almost closed by the Big Yellow mountain. The group of the Black Mountain rises nearly isolated on one side in the interval between the two chains touching by a corner the high Pinnacle of the Blue Ridge, and overtowering all the neighboring chains by a thousand feet. In the large and comparatively deep basin of the French Broad Valley, the Blue Ridge is considerably depressed, while the western chain preserves its increasing height. Beyond the French Broad rises the most massive cluster of highlands, and of moun-

tain chains. Here the chain of the Great Smoky mountains which extends from the deep cut of the French Broad at Paint Rock, to that, not less remarkable, of the Little Tennessee, is the master chain of that region and of the whole Alleghany system. Though its highest summits are a few feet below the highest peaks of the Black Mountain, it presents on that extent of 65 miles a continuous series of high peaks, and an average elevation not to be found in any other district, and which give to it a greater importance in the geographical structure of that vast system of mountains. The gaps or depressions never fall below 5000 feet except towards the southwest and beyond Forney Ridge, and the number of peaks, the altitude of which exceeds 6000 feet, is indeed very large. On the opposite side, to the southeast, the Blue Ridge also rises again to a considerable height, in the stately mountains of the Great Hogback and Whiteside, which nearly reach 5000 feet, and keeps on in a series of peaks scarcely less elevated far beyond the boundary of Georgia.

Moreover the interior, between the Smoky mountains and the Blue Ridge, is filled with chains which offer peaks higher still than the latter. The compact and intricated cluster of high mountains, which form the almost unknown wilderness covering the southern portion of Haywood and Jackson counties, is remarkable by its massiveness and the number of lofty peaks which are crowded within a comparatively narrow space. The Cold mountain chain, which constitutes one of its main axes, shows a long series of broad tops, nearly all of which exceed 6000 feet. Near the south end, but west of it, not far from the head waters of the French Broad, the Pigeon and the Tuckaseegee waters, Mount Hardy raises its dark and broad head to the height of 6133. Still further, to the northwest, the group culminates in the Richland Balsam, 6425 feet, which divides the waters of the two main branches of Pigeon river and of the Caney fork of the Tuckaseegee. Amos Plott's Balsam, in the midst of the great Balsam chain, which runs in a parallel direction between the two main chains, measures 6278 feet. Considering therefore these great features of physical structure and the considerable elevation of the valleys which form the base of these high chains, we may say that this vast cluster of highlands between the French Broad and the Tuckaseegee rivers, is the culminating region of the great Appalachian system.

New Map of the Alleghany System, by Mr. E. Sandoz.—The measurements of Professor Guyot, just referred to, furnish important data for the correction as well as the completion of all existing maps of the regions which he has examined. These data, with the exception of those collected in the past summer, have been employed by Mr. Ernest Sandoz, a nephew of Prof. Guyot, and an accomplished draftsman, in the construc-

tion of a new map of the entire Alleghany chain, which has been published in the July number of Petermann's *Mittheilungen.* Mr. Sandoz had accompanied Mr. Guyot on many of his mountain expeditions and took the results with him to Gotha, where the chart was drawn and engraved under the direction of Dr. Petermann. To the editor of that excellent repository of geographical science, we are indebted for an early and proof impression of this map. As it is by far the most satisfactory chart of the Eastern portion of the United States in existence,—a request has been sent to Dr. Petermann to permit its republication in connection with this Journal, and there is reason to hope that at no distant day it may be laid before our readers, with a paper illustrative and explanatory of it, from the pen of Professor Guyot. The new edition when issued will contain some emendations derived from the more recent surveys to which allusion has been made.

The scale of the map is 1 : 6,000,000. Two detailed subordinate maps are printed on the same sheet with it, having a scale of 1 : 600,000, one of which gives the White Mts. of New Hampshire, the other the Black Mts. of North Carolina, both according to Mr. Guyot's measurements.

NARRATIVE OF A VOYAGE TO SPITZBERGEN IN THE YEAR 1613.—In the Transactions of the American Antiquarian Society, vol. iv. just published, S. F. Haven, Esq., the Society's Librarian, has edited with an introduction and notes, a Narrative of a Voyage to Spitzbergen made in the year 1613 at the charge of the English "Muscovey Company." Although this voyage is one of the series embraced in the celebrated collection of Purchas, commonly known as "His Pilgrimes," yet this account, which has been lying among the Manuscripts of the Antiquarian Society, has never before been printed. There is reason for believing, says Mr. Haven, that the Journal now first printed was from the pen of Robert Fotherby, whose name both as an author and as a skillful navigator is connected with two succeeding voyages.

"The expedition of 1613," he continues, "was fitted out with unusual care, and intrusted to the charge of some of the ablest men in the service. Besides the chief Captain, Benjamin Joseph, William Baffin and the author of our narrative, it was accompanied by Thos. Edge, who had already twice sailed to Spitzbergen. Purchas was indebted to Edge for the map of the coast inserted in his work, and also for a summary of Northern Discoveries which appears in the same volume. Baffin was attached to the ship of the commander of the fleet; and from that circumstance, apart from his personal reputation and the value of his scientific observations, his journal would naturally be the one selected for publication. The author of our account was in another vessel

often separated from the rest. He thus experienced a different series of incidents or observed the same from a different point of view."

At this period when Arctic explorations are attracting so much attention, the printing of this early record is peculiarly acceptable. The introduction and notes, with which the paper has been enriched by the pen of its learned editor, illustrate many interesting points pertaining to polar discoveries. The cuts which accompany this edition are fac-similes (except in their size which is half that of the originals) from some rude drawings which are attached to the Manuscript.

DR. ENGELMANN'S MEASUREMENT OF THE ELEVATION OF ST. LOUIS, ABOVE THE GULF OF MEXICO.—In the Transactions of the Academy of Science in St. Louis, vol. i, No. 4, 1860, there is an article by Dr. Geo. Engelmann on the elevation of St. Louis above the Gulf of Mexico, from which the following statements are derived.

"A knowledge of the exact altitude of St. Louis is important as an element in the physical geography of North America, not only for the reason that this city stands, so to say, in the centre of the great Mississippi Valley and not far from the confluence of the four great rivers, the Mississippi, the Missouri, the Illinois and the Ohio, but, also, because most of the hypsometrical measurements throughout the northern and western regions of this valley and into New Mexico and Utah, made by the different explorers during the last twenty years and more, by Nicollet, Fremont, Owen, Wislizenus, Emory, Stansbury, and several of the Pacific Railroad exploring expeditions, took the altitude of St. Louis as their starting point, and were based to a great extent on the barometrical observations of those explorers compared with mine.

"Mr. J. N. Nicollet was the first who ascertained the elevation of St. Louis as well as a great many points on the Mississippi and Missouri rivers, as he was the first to give us a physical geography of the Mississippi Valley, based on careful instrumental observation. He laid down an abstract of his labors in his Report on the Hydrographical Basin of the Upper Mississippi, in 1841, published by order of the U. S. Senate, after his death, in 1843. On pages 93–101 he gives a detailed account of the methods employed to obtain the desired results, and on pp. 122–125 is contained a most valuable table of geographical positions, distances, and altitudes."

In this table, the altitude of St. Louis is stated to be 382 feet from which two feet must be deducted to reduce it to low water-mark.

Dr. A. Wislizenus next calculated the elevation of St. Louis. His results are published in his Report on a Tour to Northern

Mexico, printed by the U. S. Senate in 1848. They place the altitude of the present low water-mark at 389 feet 6 inches.

Dr. Engelmann's recent calculations and measurements give the height of the low water-mark at St. Louis at 374 feet 4 inches, a few feet lower than either of his predecessors had estimated it.

The following table shows their comparative results for three different points measured.

Height of St. Louis above the Gulf, in English feet.

	Nicollet.	Wislizenus.	Engelmann.
Engelmann's Barometric Station,	486·5	496·0	480·9
City Directrix,	410·5	420·0	404·9
Low water-mark,	380·	389·5	374·4

"Intimately connected with the altitude of St. Louis and other points along our river is the question of the fall of the river and the velocity of its current. Nicollet's tables, mentioned above, give us the only data at present available for an approximative estimation of the fall of the Mississippi in its different sections. The following little table, calculated from these data, explains itself:

	Distances in miles.		Fall in feet.		Fall of the River in feet pr mile
	From point to point.	Total from St. Peter's.	From point to point.	Total from St. Peter's.	
Mouth of S. Peter's River to					
Prairie du Chien,	260	260	102	102	0·39
Rock Island,	210	470	114	216	0·54
Mouth of Desmoines,	128	598	84	300	0·65
St. Louis,	204	802	62	362	0·30
Mouth of Ohio,	174	976	58	420	0·33
Mouth of White River,	462	1438	122	542	0·26
Natchez,	348	1786	116	658	0·33
New Orleans,	302	2088	76	734	0·25
Mouths of Mississippi,	104	2192	10	744	0·09
Or in the great natural sections of its course: Mouth of St. Peter's River to					
Prairie du Chien,	260	260	102	102	0·39
Mouth of Desmoines,	338	598	198	300	0·59
New Orleans,	1490	2088	434	734	0·29
Mouths of Mississippi,	104	2192	10	744	0·09
Total average fall of the Mississippi from mouth of St. Peter's River to the Gulf,					0·34

"The Mississippi River has therefore an average fall of about 4 inches per mile; between St. Peter's and the Rapids, a little more; from the lower end of the Rapids to New Orleans, a little less; in the region of the Rapids, about 7 inches; and from New Orleans to the mouth, about 1 inch per mile. A further analysis of the tables shows the fall on both rapids to be 21 inches to the mile."

Dr. Engelmann then gives the following data, based, as he says, on his own "rather loose observations" respecting the velocity of the Mississippi. As he remarks on "the absence of all other information" on this point it seems proper for us to refer to Marr's Report of Observations at Memphis in 1849, and to Dr. Ellet's work, to the measurements of Riddell, Forshey, and Dickenson reported to the American Association, and to an article by Lyell in this Journal, [2], iii, pp. 36 and 118.

Date of Observation.	Height of River above low water.	Current per hour.	One mile in
1845. Feb. 20,	5 feet,	3·00 miles,	20 minutes.
" " 28,	10 "	3·50 "	17 "
1844. Mar. 5,	15 "	4·00 "	15 "
" Ap. 26,	20 "	5·00 "	12 "
1839. May 27,	21 "	5·09 "	11¾ "
1837. July 10,	27 "	5·55 "	10¾ "
1844. May 19,	27 "	5·68 "	10½ "
" Jun. 22,	35 "	6·25 "	9¾ "

KIEPERT'S NEUER HAND ATLAS, (Berlin, Reimer: N.Y., Westermann, 1860.)—This admirable work which has been for some years in progress is at last complete, presenting a collection of forty maps of different portions of the world. They are drawn with great beauty and skill and the whole work is at once attractive, convenient and trustworthy,—as might indeed be expected from the reputation which the author enjoys as a cartographer. Our limits do not admit of an extended criticism on the several maps, but we append a list for the information of those who may wish to purchase a complete general Atlas for every day use.

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EXPLORATION OF WESTERN BRITISH AMERICA.—In the last number of this Journal a condensed account was given of the expeditions sent out by the Canadian Government for the exploration of the Red river and Saskatchewan districts. Since then, we have received several important Canadian documents, referred to in that article. As they possess a permanent value we subjoin a notice of their contents.

1. Report from the Select Committee on the Hudson's Bay Company, together with the proceedings of the Committee, minutes of evidence, appendix and index. Ordered by the House of Commons to be printed 31st July and 11th August, 1857.

This public document presents in the usual style of the Investigations of a Committee of a House of Parliament, a vast amount of matter relating to the affairs of the Hudson's Bay Company and the regions under their control,—derived from the examination of Hon. J. Ross, Col. Lefroy, Dr. Rae, Sir Geo. Simpson, Sir John Richardson and other gentlemen. It is accompanied by three maps; 1, of the British and Russian possessions in North America; 2, of the aboriginal tribes of British America; and 3, of the Northwestern portion of Canada, Hudson Bay and Indian Territories.

2. Papers relating to the Affairs of British Columbia. Part I. Copies of Dispatches from the Secretary of State for the Colonies to the Governor of British Columbia, and from the Governor to the Secretary of State relative to the Government of the Colony; also Copies of the Act of Parliament to provide for the Government of British Columbia; Governor's Commissions and Instructions; Order in Council to provide for the Administration of Justice; and Instrument revoking so much of the Crown Grant of the 20th May, 1838 to the Hudson's Bay Company for exclusive trading with the Indians as relates to the Territories comprised within the Colony of British Columbia. Presented to both Houses of Parliament by Command of Her Majesty, 18th February, 1859. London, 1859.

This blue book relating chiefly to Fraser's river and the gold discoveries has an outline sketch of the western portion of British America showing the different routes of communication, across the country to the mouth of the river.

3. Northwest Territory.—Reports of Progress together with a preliminary and general Report on the Assiniboine and Saskatchewan exploring Expedition, made under instructions from the principal Secretary, Canada. By HENRY YOULE HIND, M.A. in charge of the Expedition. Toronto, 1859.

4. Report on the exploration of the Country between Lake Superior and Red River Settlement and between the latter place and Assiniboine and Saskatchewan. By S. J. Dawson, Esq., C.E. Printed by Order of the Legislative Assembly. Toronto, 1859.

A particular account of these expeditions was given in the last number of this Journal, p. 218.

5. Geological Survey of Canada. Report of Progress for the year 1858. Montreal, 1859.

6. Map of the Northwest part of Canada, Indian Territories and Hudson's Bay; compiled and drawn by Thos. Divine, Provincial Land Surveyor and Draftsman, by order of Hon. Jos. Cauchon, Commissioner of Crown Lands, Toronto, March, 1857. Published by S. Derbeshire and G. Desbarats.

This is a map in outline, geologically colored, of the region above mentioned, extending as far north as 75° north latitude and as far south as 45° north latitude. Being made previous to the recent exploring expeditions it is now behind our present knowledge. The authorities on which it is based are J. Arrowsmith, A. Mackenzie, D. Thompson, the Admiralty and Coast Survey Charts, Pacific Rail Road Survey Reports. Sir Geo. Simpson, Governor of the Hudson's Bay Company, Sir Wm. Logan and others are also quoted. The isothermal lines are given according to Dove and Blodget.

7. Government Map of Canada from Red River to the Gulf of St. Lawrence, compiled by Thomas Devine, Head of Surveys, Upper Canada Branch, Crown Land Department. November, 1859.

This map in three sheets, is limited to Upper and Lower Canada, the counties of which are distinctly indicated by color, and the more detailed topography is also clearly given. It is clearly drawn, and presents in its margin a variety of useful information respecting the resources of Canada.

Dr. Barth in Asia Minor.—Dr. Henry Barth, the celebrated traveller in Africa, has published in a Supplement to Petermann's Mittheilungen an account of a journey which he made in 1857–1858 from Trapezund, through the interior of Asia Minor, by way of Tokat, Amássia, Yûsgad, Cesarea and Angora to Constantinople. His attention was directed to the physical structure of the country and also to the remains of ancient art. The archaeological inquiries which he made will hereafter be made public, in detail,—though many of the more important facts are brought out in Petermann with illustrative wood cuts. A sketch of his journey is given on an accompanying chart with plans of Tókat, Amássia, Kara-hissár and Kyr-schehr.

D. C. G.

ART. XXXVII.—*Further Remarks on Numerical Relations between Equivalents;* by M. CAREY LEA.

IN papers on this subject published in the January and May numbers of this Journal for the present year, I endeavored to show that a large number of so-called elements could be arranged in seriated groups, the members in each series differing from each other by a common quantity, in most cases the number 44 or one approximating to it. I endeavored to show that not only were these groups natural groups, but that the chemical properties of the members of each group corresponded in many cases with their position in it. These observations seemed to favor the view at present gradually gaining ground, that those bodies which we have as yet failed to decompose, we have not proved to be elementary.

An interesting and elaborate paper by Gustav Tschermak, published in the Proceedings of the Academy of Science of Vienna, and extracted in an abridged form in Knop's Centralblatt, (July 4, 1860,) on the subject of the law of volumes of liquid chemical compounds affords a support to the views above expressed, from a new source. The author therein shows that many of the substances usually classed as elements comport themselves in the physical properties exhibited by their combinations as compound bodies, and that it is possible from these physical properties to determine (hypothetically) the number of "physical" or absolute atoms which he supposes to be contained in a chemical atom of such body or pseudo-element. He endeavors to show that it is possible to calculate the specific gravity of a liquid from its atomic weight and the number of simple (chemical) atoms in its compound molecule, as data, but that the results lead to the immediate inference that each chemical atom contains with few exceptions several physical atoms.

For particulars of his theory I must refer to the original paper, but some of his results are as follows:

	Physical atoms to each chemical atom.*
O (O=16)	2
S (S=32)	4
F	2
Cl	4
N	2
P	4
As	5
Sb	6

* These numbers are taken from the table of mean numbers, p. 508 of Centralblatt and are those subsequently used by the author for determining the "physical atomic weights" $= \frac{m}{n}$.

If now we arrange the first six of these substances in parallel series we shall find

	Atomic weight.		Physical atoms.
Sulphur,	32		4
Oxygen,	16		2
difference,	16	difference,	2
Chlorine,	35·5		4
Fluorine,	19		2
difference,	16·5	difference,	2
Phosphorus,	31		4
Nitrogen,	14		2
difference,	17	difference,	2

Thus a common difference in each case amounting to 16–17 corresponds with a difference of two of the physical atoms into which Tschermak divides the chemical atoms.

If now we put O=2o, Cl=2cl, P=2p, the approximate difference between S and O, Cl and F, &c., (16–17)=2Δ', the difference (48) between S and Se=Δ'' and the difference (44–45) between the terms of the nitrogen series =Δ, we can express the whole of three important series in terms of these six quantities, so that at one and the same time both the numerical value of the atomic weights and the number of Tschermak's physical atoms shall be correctly expressed.

	Symbols.	At. weights.	Physical atoms.
A. Oxygen group.			
Oxygen,	o_2	16	2
Sulphur,	$o_2\Delta'_2$	32	4
Selenium,	$o_2\Delta'_2\Delta''$	80	5
Tellurium,	$o_2\Delta'_2\Delta''_2$	128	6
B. Chlorine group.			
Fluorine,	fl_2	19	2
Chlorine,	$fl_2\Delta'_2$	35·5	4
Bromine,	$fl_2\Delta'_2\Delta$	80	5
Iodine,	$fl_2\Delta'_2\Delta_2$	127	6
C. Nitrogen group.			
Nitrogen,	n_2	14	2
Phosphorus,	$n_2\Delta'_2$	31	4
Arsenic,	$n_2\Delta'_2\Delta$	75	5
Antimony,	$n_2\Delta'_2\Delta_2$	120·3	6

In which table the number of radicals by which the chemical atom of each body is expressed, corresponds with the number of Tschermak's physical atoms, while their numerical value is equal to the atomic weight of the body.

Thus tellurium $o_2\Delta'_2\Delta''_2$ would have two each of three radicals, in all six, agreeing with the number of physical atoms as-

signed to it, while their value $2\times8+2\times8+2\times48=128$, at. wt. of tellurium.

These observations of Tschermak, taken in connection with the numerical relations which exist between atomic weights, give rise to very interesting results, and if the conclusions which he arrives at from his experiments should be confirmed, they cannot fail to exercise a very important influence on the progress of chemical science.

Philadelphia, August 28th, 1860.

ART. XXXVIII.—*On the Production of Ethylamine by Reactions of the Oxy-Ethers*; by M. CAREY LEA.

[Read before the Am. Assoc. for the Adv. of Sci. at Newport, August, 1860.]

WHILE engaged in making a series of experiments on this subject I met with the paper of Juncadella* and the observations of De Clermont† on the same subject. Finding that the subject had less novelty than I supposed I merely offer here one or two of the results which I have obtained.

Nitrate of ethyl C_4H_5O, NO_5 heated in sealed tubes with chlorid of mercurammonium $\left.\begin{matrix}H_3\\Hg\end{matrix}\right\}NCl$ for many hours in the water bath did not appear to react upon it. Kept for some time in a boiling saturated solution of chlorid of calcium the tubes although extremely thick green glass-combustion-tube of small calibre was used, exploded with great violence, shattering the vessel in which they were contained, although they had been wrapped in strong cloth.

Nitrate of ethyl heated in a sealed tube with chlorid of zinc-ammonium $\left.\begin{matrix}H_3\\Zn\end{matrix}\right\}NCl$ in the water bath, does not appear to act upon it.

Nitrate of ethyl heated in the water bath in a sealed tube with carbamate of ammonia $NH_4O, NH_2C_2O_3$ dissolves the salt. On cooling radiated crystals form. The contents of the tube evaporated to dryness with excess of chlorhydric acid, and then exhausted with ether to which a few drops of strong alcohol have been added, yielded a solution which gave a chamois colored precipitate with bichlorid of platinum, consisting of chloroplatinate of ethylamine.

·1185 gm. substance gave ·0465 metallic platinum corresponding to 39·25 per cent; theory requires 39·29

The product was but small. Probably portions remained undissolved by the ether. No doubt portions of di- and tri-ethylamine are also formed in the above reaction, in the same manner as in those of the halogen ethers with ammonia.

Philadelphia, July 11, 1860.

* Rép de Chimie pure, Tome 1, 273. † Ibid., 274.

Art. XXXIX.—*On the Optical Properties of the Picrate of Manganese;* by M. Carey Lea, Philadelphia.

[Read before the Am. Assoc. for the Adv. of Sci. at Newport, August, 1860.]

Brewster and Haidinger have described a remarkable property possessed by certain crystalline surfaces, of reflecting, besides the ray normally polarized in the plane of incidence and reflection, another ray, polarized perpendicularly to that plane, and differing from the former in being colored, a property rendered more conspicuous by the fact that the color of the ray so polarized abnormally is either complementary to, or at least quite distinct from the color of the crystal itself.

I find that this property is possessed to a remarkable degree by the picrate of manganese. This salt crystallizes in large and beautiful transparent right rhombic prisms, sometimes amber-yellow, sometimes aurora-red, exhibiting generally the combination of principal prism, and macrodiagonal, brachydiagonal and principal end planes. In describing this substance in a paper on picric acid and the picrates,* I mentioned that in a great number of specimens examined, no planes except those parallel with or perpendicular to the principal axis had been met with. Since then I have obtained in several crystallizations specimens exhibiting a brachydiagonal doma, but this appears to be rather unusual.

The optical properties of this salt are very interesting. It exhibits a beautiful dichroism. If the crystal be viewed by light transmitted in the direction of its principal axis, it appears of a pale straw color, in any other direction, rich aurora-red in some specimens, in others salmon color. A doubly refracting achromatised prism gives images of these two colors, except the light be transmitted along the principal axis of the crystal of picrate, in which case both are pale straw color.

But it also possesses in a high degree the property of reflecting two oppositely polarized beams, and the great size of the crystals in which it may readily be obtained, renders it peculiarly fitted for optical examination. If one of these crystals be viewed by reflected light while it is held with its principal axis lying in the plane of incidence and reflection, the reflected light is found to be not pure white, but to have a purple shade. Examined with a rhombohedron or an achromatised prism of Iceland spar, having its principal axis in the plane of incidence and reflection, the ordinary image is white as usual, while the extraordinary is of a fine purple color, the phemenon having the greatest distinctness when the light is incident at the angle of maximum polarization.

* This Journal, Nov., 1858.

The experiment may be varied and the purple light beautifully seen without the use of a doubly refracting prism by allowing only light polarized perpendicularly to the plane of incidence to fall on the crystal; in this case the surface of the crystal appears rich deep purple, no white light reaching the eye.

This property is not possessed by all the planes of the crystal, but is limited to the principal prism and brachy- and macrodiagonal end planes, in other words to the planes parallel with the principal axis of the crystal. The brachydiagonal doma and $0P$ planes do not possess it. Nor is it exhibited by the first mentioned planes, when the crystal is turned with its prismatic axis at right angles to the plane of incidence.

All specimens of picrate of manganese do not possess this property to an equal extent. The crystals vary considerably in color, and those which are full red exhibit it more strongly than the amber colored. Picric acid boiled with aqueous solution of cyanhydroferric acid and saturated with carbonate of manganese gives crystals of a rich deep color, which exhibit the purple polarized beam particularly well.

These properties are not possessed by the manganese salt alone, but also by the picrates of potash and ammonia, (especially when crystallized by very slow spontaneous evaporation in prisms of sufficient size) and the picrates of cadmium and peroxyd of iron —with this difference however, that while the prismatic axis of the crystal in the case of the cadmium and manganese salts must be in the plane of incidence, in the alcaline salts it must be perpendicular to that plane. As they all crystallize in the right rhombic system, it is probable that either the alcaline salts on the one hand, or the manganese and cadmium or the other, are prismatically elongated in the direction of a secondary axis.

It is convenient that distinct phenomena should have distinct names, and none appears to have been assigned to this. Brewster speaks of it as a "property of light," and Haidinger uses the word "Schiller" for it. The terms dichroism, trichroism and pleiochroism are limited to properties of transmitted light. I therefore suggest for that here in question the name *catachroism*, using the preposition κατα in the same sense as in the word καταστρεφω, to reflect, (as a polished surface,) applying it to express the property of reflecting two beams, one normally polarized in the plane of incidence and the other polarized in a plane perpendicular to it.

The chromatic properties exhibited by the picrates of ammonia and potash are very remarkable in their variety. Their crystals possess:—

1st. The well known play of red and green light. If a little very dilute solution of pure picrate of potash be spontaneously

evaporated in a hemispherical porcelain basin, so as to form a net work of extremely slender needles, and these be viewed by gas light, the play of colors is singularly brilliant.

2d. Dichroism. When by spontaneous evaporation of large quantities of solution of potash, or better, of ammonia salt, transparent prisms of $\frac{1}{12}$ to $\frac{1}{15}$ inch diameter are obtained, these, viewed with a doubly refracting prism by transmitted light give two images, one pale straw color, and the other deep brownish red.

3d. The above described property of catachroism, or reflection in the plane of incidence of oppositely polarized beams.

Philadelphia, August, 1860.

ART. XL.—*On our inability from the Retinal impression alone to determine which Retina is impressed;* by Prof. WILLIAM B. ROGERS.

[Read before the Am. Assoc. for the Advancement of Sci., at Newport, Aug. 1860.]

ALTHOUGH on first view it might be supposed that an impression made in either eye must necessarily be accompanied by a mental reference to the particular organ impressed, it will be seen from the following simple experiments that the impression of itself is not essentially suggestive of the special retinal surface on which it is received.

Exp. 1. Let a short tube of black pasteboard $\frac{1}{2}$ inch in diameter be fixed in a hole in the centre of a large sheet of the same material. Hold the sheet a few inches before the face of a second person and between him and a bright window, moving it to and fro until the bright circular aperture of the tube is brought directly in front of one of the eyes, suppose the left eye; and let him fix his attention upon the sky or cloud to which the tube is directed. He will feel as if the impression or image of the hole *belongs equally to both eyes* and will be unable to determine which of them really receives the light.

On moving the aperture towards the right, or nearer the nose, but not so far as to be out of the view of the left eye, or to be visible by the right, the observer will imagine that it is now in front of the right eye and chiefly seen by it. Shifting it still further in the same direction, until it is brought within view of the right eye but not fairly in front of it, it will appear as if placed before the left eye, and by an additional motion bringing it fairly in front of the right eye it will seem to be equally before both eyes or to be in the medial line between them.

Like effects may be observed by using a half sheet of rather stiff foolscap with a large pin hole in the centre. Bending this over the face and moving it until the hole is in front of one of

the eyes, the same uncertainty and contradiction will be produced as in the preceding experiment.

Exp. 2. Similar results may be obtained by rolling half a sheet of letter paper into a tube of about one inch in diameter, and holding it before and a little in advance of one eye while both are directed to a white wall some feet distant. Keeping the view *fixed* upon the wall there will be seen upon its surface a circular image of the remote aperture of the tube. This as we look intently at it will appear as if seen equally by both eyes, occupying a midway position between them. If now the eyes be converged to some point nearer than the end of the tube the circular image will appear against the side of the tube giving the impression that it is seen by the eye which is remote from the tube and is at the same time directed toward the outside. For the complete success of this experiment the wall should be only moderately bright, and but little light should fall on the exterior of the tube next the uncovered eye.

Exp. 3. Let two tubes of stiff paper each one inch in diameter and six inches long be held close to the two eyes in a converging direction so that the outer ends may touch each other. Then directing the view through them to a white wall at a short distance, the observer will see the two tubes as one, with a single circular opening clearly marked out on the wall. If now a small object as the end of the little finger be brought near and in front of one of the tubes, it will take its place within this circle and will seem to be equally an object of vision to both eyes, so that the observer will be wholly unable to decide before which eye it is actually placed.

Let the observer next direct his view to a very remote object, as the sky, seen through the window, still retaining the previous adjustment of the tubes. He will now see two circles, continuing separate as long as he keeps his eyes fixed on the distant surface; and if the finger be held up as before in front of one of the tubes it will appear within the circle which is in front of *the other eye;* thus causing the impression on the right eye to be apparently transposed to the left, and vice versa.

Exp. 4. Fasten a small disc of white paper on a slip of black pasteboard of the size suitable for a stereoscope, and place this in the instrument so that the white spot shall be centrally in front of one of the glasses.

To a person not aware of the position of the spot it will appear in the stereoscope as if equally in view to both eyes and he will be entirely unable to decide on which retina its picture is impressed. Indeed properly considered the spot does not appear directly in front of either eye but is seen at the intersection of the optic axes, in the medial or binocular direction between the two.

Let the spot be now moved toward the right side but still within the range of the left eye and it will seem to be before the right eye rather than the left. Shift it into the right compartment but not far from the dividing line and it will appear as if seen chiefly by the left eye, and finally bring it to the middle of the right compartment and it will seem as at first to belong equally to both eyes.*

Referring to the results observed in the above experiments when the object is directly in front of either eye it may be concluded that the mere retinal impression, on either eye is unaccompanied by any consciousness of the special surface impressed, and that the formation of the visual perception appertains to that part of the optical apparatus near or within the brain, *which belongs in common to both eyes.*

These observations show moreover that the *perceived direction is just as truly normal to the central part of the retina which has received no light as to that of the retina on which the white spot has been painted.* Indeed as before indicated, it is normal to neither, but is felt to be in the middle line between the two, that is, in the binocular direction. It need scarcely be added that this conclusion is at variance with the law of visible direction maintained by Brewster, which requires that the apparent direction of an object shall in all cases be normal to the part of the retina impressed.

The reference of the object in certain cases above noticed, (parts of 1, 2 and 4) to *one eye chiefly*, and that the eye from which *it is actually hidden*, is accounted for by the direction in which the other eye receives the light. As this direction, in the case of the left eye for instance, would be decidedly toward the field of view of the right eye, it would at once suggest the place of the object as somewhere before that eye, and so when the object is actually before the right eye, but in a position towards the left, it would excite the idea of an object somewhere before the left eye. As the retinal picture alone gives no indication of the particular eye in which it is formed, but only excites a visual consciousness common to both, the object in these cases will seem to be visible by both eyes but chiefly by that before which the suggestion just mentioned would naturally place it.

A like explanation applies to the transposition observed in Exp. 3, when the view is directed to a distance through the converging tubes. Here the false visual reference of the finger depends on the fact that the circle in front of either eye is sugges-

* The effect here described is one of a series of phenomena which Dr. O. W. Holmes attributes to an *actual transfer* of impressions from one eye to the other, and which he proposes to explain by the hypothesis of reflex vision. Proc. Am. Acad. Arts and Sciences, Feb. 1860.

tive, merely by its position, of a *special vision by that eye*, while from the conditions of the experiment these circles are in fact reversed in their places as compared with the tubes and eyes to which they appertain.

We have seen in the above experiments that when an object is presented to one eye without any accompanying circumstances leading us to refer the visual act specially to this or to the other eye we have a consciousness of seeing it equally with both eyes. *The same result occurs when separate objects are presented to the two eyes*, provided as before, extraneous sources of suggestion are excluded.

Exp. 5. Thus if we place on the black slide of the stereoscope two spots, differing either in shape or color, one before each eye, we perceive them both in the middle or binocular direction, each seemingly visible in an equal degree to both eyes, the one being seen through or upon the other according to the fitful attention or suggestion of the moment. A pleasing modification of this experiment is made by using two unequal white spots on the black slide and interposing a green or other colored glass between one of them and the lens. The spot which appears colored will give as strongly the impression of being seen by both eyes as the white one, in spite of our knowledge of the position of the colored glass.

Even in cases where the two objects are wholly unlike, and at very different distances from the eyes by which they are severally regarded, this feeling of a common or united visual act in regard to each of them is often easily recognized. Of this we have a ready illustration in the familiar experiment on ocular parallax in which a distant object, hidden from one eye by an interposed finger or pencil, is seen through or behind the pencil when both eyes are directed towards the distant object.

Exp. 6. To observe this effect satisfactorily it is well to make the experiment in an apartment in which a single small lamp is placed at some distance from the spot on which we stand. Looking intently at the lamp, we bring the pencil before the face in such position as to give us an image on each side of the lamp, and then move the pencil toward the right until its left hand image seems to coincide in direction and position with the lamp, which appears to shine through or to partially replace it. As we continue to look thus at the lamp, we have a clear impression that both lamp and pencil are equally visible to both eyes, and without some consideration of the previous adjustment and motions we are unable to determine which is actually visible to the right and which to the left eye.

The same experiment furnishes also an incidental illustration of the principle of *transposed* visual reference before alluded to.

If, while the above adjustment is maintained, we contemplate the other image of the pencil situated some distance to the right of the lamp, and endeavor to decide, from the mere visual impression, to which eye it appertains, we almost unfailingly refer it to the right eye as that which most nearly fronts it, although obviously it belongs to the other, as will be found at once on closing either eye.

Where the eyes are externally very sensitive, any strong illumination of one as compared with the other will interfere with the effect above described by referring the impression specially to the eye thus unduly excited. In such cases the observation is best made in a moderately lighted room by interposing the pencil between the eye and a vertical stripe on the wall.

Exp. 7. Recurring to Exp. 2, in which with a tube in front of one eye we perceive a bright circle on the wall in the medial direction, we may obtain a pleasing illustration of the point now under consideration by bringing a dark card or book or even the hand between the uncovered eye and the wall. The spot instead of being intercepted will appear as a perforation in the opaque screen.

Here as in the case of the pencil and lamp, the bright circle and the screen are both optically referred to the intersection of the two lines of view. But the luminous circle almost or entirely obliterates the corresponding part of the screen. As the full view of the screen and its connections continually remind us that it is in front of the uncovered eye, we are led to refer the luminous circle seen as coincident with a part of it, to the same eye, and thus to believe that *we are looking through the screen with that eye.* It is however not difficult, by intently regarding the luminous circle, so to counteract the force of this extraneous suggestion as to feel even in this case as if the circle were equally in view to both eyes.

These considerations explain very simply the experiment of the pseudo-diascope described by Mr. Ward of Manchester, which like several of those above mentioned is but an instance of the old observation of Da Vinci, that when we see behind a small opaque object presented near the eyes "it becomes as it were transparent." In making this experiment with a tube of paper supported between the thumb and forefinger of the left hand and held before the right eye so that the back of the hand may be some inches in advance of the left eye, it will be noticed that the effect varies with the amount of convergence of the eyes and that the bright perforation in the hand *may or may not* be referred to the left eye according to the force of the accessory suggestions or the intentness with which we fix our gaze upon the distant spot to which the axes are converged.

In concluding, it may be remarked that the experiments which have been described are for the most part too obvious and familiar to have merited such a special notice but for the peculiar and in some respects new interpretation which they have offered of many visual phenomena. Considered in this relation we are I think entitled to conclude from them:—

First that the retinal impression of an object presented directly to either eye is accompanied by the feeling of a united visual act, and of itself gives no indication of the particular eye impressed; and:—

Second, that the reference of the impression to one eye rather than the other is the result of collateral *suggestion*, which may either locate the image in the eye that actually receives it, or may transpose it seemingly to the other, according to the particular conditions of the observation.

ART. XLI.—*Correspondence of J. Nicklès, of Nancy, France.*

Physical Chemistry.—Polarized Light employed as a Reagent.—BIOT, who entered his 86th year on the 21st of April last, and who continues to labor with the ardor of youth, has just published a résume of his complete works on circular polarization, applied to the study of chemical species. These researches, which he has greatly promoted, have often occupied us and daily gained more importance. Biot has given us the following account of the manner in which he was led to the discovery of the fundamental fact which has given point to all his labors in this field. He says:—

"Accident, that great promoter of physical novelties, gave me in 1815 the first hint in some experiments made for an entirely different object.

Wishing to study the changes of a polarized ray, when it passes very obliquely through thin plates of sulphate of lime, I had enclosed such a plate in a large metallic tube, about 8 centimetres long terminated by parallel faces of glass, and filled with colorless essence of turpentine. This was attached to a metallic rod projecting out transversely, which turned on its axis around the centre of a graduated circle, allowing me to change at pleasure the inclination of the interior incidence of the polarized ray. Having thus brought the plane of the plate in the direction of the ray itself, so as to fix the point of departure of their inclinations, the principal section of the analyzing prism being previously placed in the plane of the primitive polarization so as not to disturb it, I perceived in that part of the field of view occupied by the essence an indistinct, extraordinary image, of a blue color, caused by the interposed essence.

Water and alcohol previously introduced into the same tube, produced nothing similar. The effect observed, was not therefore due to the interposition of the essence, as a *liquid* mass. It must necessarily result from some physical property, peculiar to the substance which produced it.

I hence inferred that there was a deviation from the plane of polarization, to the right or the left, as in plates of quartz cut perpendicular to the axis. Revolving the analyzing prism successively in these two directions, towards the left, the blue image gradually grew fainter, until at a few degrees distance, it disappeared entirely, and reappeared beyond colored red, which I had found to be a distinctive character of rotary phenomena produced by plates of left-handed quartz. Hence I immediately concluded that a phenomenon of the same kind, was here presented except that it was produced by the successive actions of similar particles of the essence."

The principal fact, its molecular character, and the general consequences which are deduced from it, were made known to the Academy of Sciences, the 23d of October, 1819, and were published in a few days after in the Bulletin of the Philomathic Society of the same year, p. 190.

Since then Biot has most perseveringly prosecuted these general studies and labored to have chemists adopt them as a means of studying the intimate constitution of bodies without decomposing them, inasmuch as chemical analysis is applied to the study of those bodies only after they have ceased to exist: he explains the difficulties he has surmounted in persuading chemists to adopt this method. It is credible that these difficulties would not have been overcome, if the author of circular polarization had been an obscure *savan*—just as the value of the beautiful discoveries of Pasteur, would not yet have been recognized had not Biot been their interpreter. Biot closed his recapitulation of the principal discoveries of which the circular rotatory power of molecules had been alike the occasion and the instrument by the reflection, if his investigations had left undiscovered other facts of a kindred nature, no one could regret the involuntary omission more than himself.

On the existence of new simple bodies.—The beautiful labors which Bunsen and Kirchhoff have recently published (see page 415) on this interesting topic, the great advantage which they derive from the wonderful and peculiar action of the different metals upon the solar spectrum, the use made of it for qualitative chemical analysis and which they propose to make of it, in investigating the nature of the light of the sun and the fixed stars,—all these and many other questions raised by their memoir, have recalled attention to a research published ten years ago by Leon Foucault on the rays of the electrical spectrum. This physicist first proposed the use of points of gas carbon to form the voltaic arc.*

In studying this arc in 1847–48, he discovered that the ray D of the electrical spectrum coincides with that of the solar spectrum, and hence we may produce a superposition of two spectra, by throwing on the voltaic arc a solar image formed by a convex lens. When metals, which produce the ray D only feebly, as iron or copper, are used as poles, remarkable intensity can be secured, by touching them with a salt of potash, soda, or lime.

Foucault further adds:—"Before inferring anything from the constant presence of the ray D we must ascertain if its appearance does not indicate the same material mingled with all our conductors. Still this phenom-

* L'Institut, Feb'y, 1849; see also this Journal, [2], xxix, 424.

enon urges us to study the spectra of the stars—for if fortunately the same ray were there found, stellary astronomy would be advanced."

We recall in fact, that relying on their own observations, Messrs. B. and K. have admitted the presence of potassa and soda in the sunbeam, (*Journal de Pharmacie et de Chimie*, May, 1860, and this Journal, xxix, p. 424.) in the complete account they lately gave in Poggendorff's Annals, T. cxl, p. 161. These savans have shown how sensitive this characteristic is that even infinitesimal traces of potassa, soda and lithia can be recognized in the rays they produce and these characteristics continue even when the bases are reunited.

We will not dwell further upon this important research which is elsewhere presented in this Journal: but we should point out another direction of these researches, that which relates to the discovery of new simple bodies. Messrs. Bunsen and Kirchhoff made known lately the probable existence of a fourth alkaline metal, placed in relation to the rays of its spectrum immediately after lithium and preceding strontium.

It is thought that this process will determine the existence of the new metal dianium announced by M. Kobell (this volume, July, 1860, p. 123) and whose reality is contested by H. Rose.

Catalysis and Contact Actions.—The class of phenomena in chemico-physical research which for the want of a better term we distinguish as above, has been enriched by the discoveries of H. Loewel,* whose researches have remained hitherto too little known, but which demand attention from the very original facts they have brought to light; which are the fruits of several years of observation.

His researches on supersaturated saline solutions.—It is well known that a supersaturated solution of crystallized sulphate of soda exposed to the air crystallizes suddenly when touched by a glass rod, but that it does not crystallize when this rod is heated to 100° C. This fact is connected with many investigations which Loewel followed for a part of his life, and which are the subject of a critical analysis published by Hirn, a pupil of Loewel, who is well known by his interesting researches on heat.

Hirn's analysis of his teacher's results has rather the character of a dissertation filled with new facts, which although they may have been disputed, have yet remained so hidden in the diffuse memoirs of Loewel that they appear, as it were, now for the first time. As the research is too long to reproduce here, we content ourselves with citations from it.

* Poggendorff's Biographical Dictionary speaks of this Author thus: "Loewel, Henri, Director of the chemical works at Choisy-Le-Roi, from 1815 to 1819, since then colorist at Münster (Upper Rhine), born on the 29th of Sept. 1795 at Münster, died 5th of Sept. 1856, at Colmar: his published researches are:—

Upon some salts of chromium, *Annales de Chim. et de Phys.* (Ser. iii, T. xiv, 1845.)

Upon the chlorids of chromium (ib. xv, 1845.)

On the supersaturation of saline solutions (ib., xxix, 1850, xxxiii, 1851, xxxvii, 1853, xliii, 1855, xliv, 1855, xlix, 1857.)

Upon the action of zinc and iron upon the solution of the salts of sesquioxyd of chromium (ib., xl, 1854).

On the solubility of the carbonate of soda (ib. xliv, 1855).

On the chlorohydrate and sulphate of chromium (*Comptes Rendus*, xx, 1845.) See also *Le Recueil du Journal de Pharmacie et de Chimie*, which has also published these memoirs, a little earlier than the dates above quoted."

Reverting to the experiment with a supersaturated solution of sulphate of soda, we see it is the *air* adherent to the glass rod which determines the act of crystallization, since if the rod is heated to 100° C. no such result follows. Is it then the air which suffices for this action or some peculiar quality contained in the air? The latter supposition seems the most probable since it is not caused by air which has been filtered through cotton contained in a tube, nor by air which has passed through a properly arranged series of flasks connected by tubes of glass. Air thus agitated or heated by friction, may be brought in contact with the supersaturated solution, under the form of a continued current, without determining the crystallization, which commences immediately in presence of normal air. Loewel attributes the modification produced by the air to the friction produced in his mode of experiment, and a recent experiment of Hirn proves that it is so.

The air thus rendered passive by Loewel is called *adynamic* air. Hirn has observed that the air is rendered completely adynamic when it escapes after compression in the form of a jet from the receiver in which it was confined. After this compression it can be directed with impunity into a solution of sulphate of soda saturated by heat in a closed vessel. On the contrary, the solution solidifies instantaneously if by the same tube, and without any derangement of the apparatus, some bubbles of ordinary air are allowed to pass into the solution. Here then, is an action purely mechanical which replaces the action of heat, a remarkable example of the correlation of force which raises a crowd of questions and which leads to the inquiry if an identical composition of the air should always have an identical action upon a living being; if air rendered adynamic by a storm is not found in different conditions in relation to organized beings than air long undisturbed.

This brings to mind that Schrœder and Busch have shown that fermentation is not caused by air filtered through cotton, and we now ask if the air rendered adynamic by the process of Hirn will not possess still more passivity.

It is an argument more in favor of this theory now held by the advocates of spontaneous generation to know that it is not by germs of infusoria suspended in the air that fermentation or putrefaction is carried on. These experiments appear to us to touch questions of the greatest importance in the sciences of observation, as well as others relating to the most interesting considerations in cosmogony.

Empiricism.—Application of the Physical Sciences to Medicine.—A discussion which has recently taken place in the Academy of Medicine on the action of iron used as a medicine has made known to us this unexpected fact that there are physicians who deny any influence exercised by medicines in virtue of their chemical properties, and who think that the physical and chemical actions of the animal economy differ entirely from those which are observed in the vegetable kingdom.

At the head of this retrograde school (which ignores the progress made by physics and chemistry in the last eighty years and to whom organized beings are composed of a material which is not subject to the general laws of matter which composes the universe) appears a physician celebrated more than the rest, Dr. Trousseau, who raising the banner of

vitalism has declared that chemical laws explain nothing when used in relation to man, and that medicinal agents act by unknown and very different means from those which chemists suppose. Space does not allow us to notice the reply made at the same sitting by another physician, Poggiale, who is also somewhat of a chemist. But we shall be asked what is the precise meaning of *vitalism?* *Vitalism* is a force in the category of what has been called catalytic force; this is a word which conceals our ignorance and which is evidently an obstacle to progress. This recalls that saying of Liebig, "If we allow forces to be created, investigations become useless and it will be impossible to arrive at the knowledge of truth." Vital force is then entirely for those physicians who ignore the first notions of physics or chemistry and think all has been said when they have installed this senseless word in place of an organic fact which ranks under the laws of mechanics, physics or chemistry. Vital force is insufficient to explain how it happens that a large number of substances, such as sugar, tartaric and malic acids, sulphur, sulphurets, salicine, &c., &c., undergo in the animal economy the same changes as when subjected to chemical action.

When we remember that slight compression of a muscle suffices to develop heat, and that its contraction evolves electricity, that in order to establish chemical action it suffices to place two heterogeneous bodies in contact—one is surprised that medical men should seek to explain the phenomena of life by "vital force"; as if the material of our bodies was exempted from the laws that regulate matter, as if what they call vital laws could interfere with the play of physical, mechanical, or chemical laws.

The discussion is not yet closed. It is still continued in the Medical Journals, some of which like M. Trousseau are vitalists in pathology and empirics in the domain of therapeutics.

*Electro-Magnets and Magnetic Adhesion.**—We have on several occasions given in this Journal the progress of our researches upon magnetic adhesion, as well as the laws which regulate electro-magnets. At the request of several physicists and mechanics we have published the whole of our researches upon this subject, and a small octavo volume under the above title is the result. For the two electro-magnets, the rectilinear and the horse-shoe which were known in 1850, we must now substitute a larger number (several hundred) differing from each other by determinate properties. All these new electro-magnets which are described in this book, or whose existence has been foreseen, have at first rendered our task very difficult, for we were obliged to give names to them in order to facilitate their study. To give them such names as '*horse-shoe*' only rendered their study more difficult, we therefore preferred to group them under a systematic nomenclature according to the principle of their natural classification.

We divide the electro-magnets into two great classes according to their form, these are:—

1. Branched Electro-magnets.
2. Disk-shaped Electro-magnets.

* *Les Electro-aimants et l'adhérence magnétique.*

These classes are subdivided into families which rank according to the number of branches or disks of which they are composed; thus the rectilinear electro-magnet having only one branch will form the first family. The electro-magnet with two branches will serve as a type of the second family which will be that of bifurcated magnets, and the trifurcated electro-magnets or those with three branches form the third family; and finally the fourth family is composed of multifurcated electro-magnets, i. e., those with more than three branches. The families of electro-magnets stop here; there are consequently no *quinto, sexto . . . n* furcated electro-magnets, experience having shown that the properties of electro-magnets with more than three branches are very much the same, one new branch adding no new property.

The same method is followed with disk-shaped electro-magnets whose name is derived from *dromos*, course, in order to distinguish their most characteristic property, that of turning or revolving. These electro-magnets are divided into two groups, viz:

1st. Para-circular. 2d. Circular.

The first group is subdivided into *para-circular uni-dromes*, *bi-dromes*, *tri-dromes*, or *multi-dromes*, according as they are composed of one, two, three or more disks, in the same manner as for the branched electro-magnets.

Thus the three groups of electro-magnets are composed each of four families. These are subdivided into *genera*, determined by the *number* of helices; into *species*, characterized by the nature of the poles; and finally, into *varieties*, determined by the intensity of the latter.

The number of helices is expressed by the Greek words *monos*, *di*, *tri*, . . . *knemes*, from *κνημίς-ίδος*, (a greave or leggin,) the nature of the poles by the words *isonomes* or *antinomes*, and their intensity by the words *isodynamic* and *heterodynamic*. The use of these expressions requires some explanation, one fact heretofore unperceived in electro-magnets, one to which at least no importance has been attached, is that we use this apparatus without inquiring if the poles have the same or different intensities; and yet we have shown on several occasions:* 1st, that there is a great difference between electro-magnets of two categories and a difference no less great between bifurcated electro-magnets with poles of the same name or poles of different name.† Take for example, the horse-shoe, which has only one bobbin or spool, and which for that reason is called *electro-aimant boiteux*; it has two poles of unlike names, but these two poles are of different intensity; if we apply to this magnet the above nomenclature we shall have a *bifurcate monokneme* electro-magnet, with *antinome* and *heterodynamic* poles which consequently teaches us the properties of this apparatus just as the expression "sulphate of potash" tell us much more of the composition of that ternary than did the *Sal polychrestum Glaseri* of the alchemists.

If the question is in regard to the common horse-shoe magnet we shall say *Bifurcated dikneme*, for the circular magnets with three disks before described;† then we shall call them *tridome dikneme;* that of the two disks‡ we shall call *bidome dikneme* with isodynamic poles or with heterodynamic poles according as the helix is placed symmetrically or otherwise.

* This Journal [2], xv, 107 and 383. † Vol. xvi, p. 110. ‡ Vol. xx, p. 101.

This very simple classification suggests the kindred simplicity of symbolical notation in chemical compounds. Space fails us to pursue this question farther, as well as many others agitated in this work in which the theoretical points particularly discussed are the following :—

Of isodynamic and heterodynamic poles—Of anomalous poles (*points conséquents*)—Of magnetic phantoms—On the power of electro-magnets as affected by 1st, the elongation of the legs, 2d, the position of the helices, 3d, the distance between the poles—Of armatures—Of the form of polar surfaces—New process for measuring the effective power of electro-magnets—Of magnetic adhesion—Magnetization of locomotive wheels.

The latter process, which we have already described in this Journal (vol. xvi, [2], 337,) has since been successfully repeated in the United States, as we learn from a paper read by Mr. Blake at the Am. Sci. Assoc., 1859.

This work is illustrated by five large plates.

Nancy, Aug. 20, 1860.

SCIENTIFIC INTELLIGENCE.

I. CHEMISTRY AND PHYSICS.

1. *Chemical Analysis by Observations of Spectra.*—It is well known that many substances when introduced into a flame, possess the property of causing in the spectrum, certain bright lines. Bunsen and Kirchhoff have based upon these lines a method of qualitative analysis which materially extends the domain of chemical reactions, and leads to the solution of many difficult problems. In the present memoir, the authors develop the method for the metals of the alkalies and alkaline earths.

The lines in question become more distinct the higher the temperature and the less the specific illuminating power of the flame itself. Bunsen's gas lamp which gives a flame of very high temperature and very low illuminating power is therefore peculiarly adapted to these experiments.

The apparatus employed by the authors is sufficiently simple and does not require a large apartment for its successful use. It consists essentially of two telescopes and a hollow prism filled with bisulphid of carbon, and having a refracting angle of 60°. The eye-piece of one of the telescopes is removed and a metal plate substituted having a narrow slit which is placed in the focus of the objective lens. The lamp is placed before this slit, so that the border of the flame lies in the axis of the telescope. The substance to be examined is placed in a little loop on the end of a fine platinum wire, and is supported in the flame, a little below the point where this is intersected by the axis of the telescope. The rays diverging from the slit are made by the objective to fall upon the prism, and after refraction are received upon the objective of the other telescope the magnifying power of which is about four. The slit should be so wide that only the most distinct of the dark lines in the spectrum are visible. The lower part of the prism carries a small mirror : a telescope directed towards this mirror permits the observation of the image of a horizontal scale placed at a short distance. By turning the prism, the whole spectrum of the flame may be made to pass by the vertical wire of the observing telescope, and every part of the spectrum to correspond with this

wire. A reading of the scale is to be made for each position of the spectrum; this reading however is not necessary for those who know the particular spectra by repeated observation.

Bunsen and Kirchhoff show in the first place, that the different states of combination of the metals examined, as well as very great differences of temperature in the flames produced, exert no influence on the position of the spectral lines corresponding to the particular metals. The same metallic compound gives a spectrum which is the more intense the higher the temperature of the flame; moreover, the most volatile compound of any particular metal always gives the greatest intensity of light.

When small pieces of potassium, sodium, lithium and calcium, are attached to the extremities of fine platinum wires enclosed in glass tubes and the spark of a Ruhmkorff's induction-apparatus is allowed to pass from one pole to the other—the spectra are found to contain the same bright lines as the flames. From this, it appears that these bright lines may be looked upon as certain indications of the presence of the metals in question. They serve as reactions by which these substances may be recognized more sharply, more quickly and in smaller quantities, than by any other analytical process.

The authors give in their memoir colored drawings of the spectra produced by the flames of the six alkaline and earthy metals, together with the pure solar spectrum for the sake of comparison: for these however, we must refer to the original memoir. The special results of the investigation, are as follows:

Sodium.—The spectral reactions of sodium are the most delicate of all. The yellow line Na α the only one found in the sodium spectrum corresponds to Fraunhöfer's line D, and is remarkable for its particularly sharp definition and its extraordinary brilliancy. If the temperature of the flame is very high, and the quantity of substance employed very large, traces of a continuous spectrum are observed in the neighborhood of the line. For this reason, faint lines in the spectra of other substances only become visible, in many cases, when the sodium reaction begins to fade away. The reaction is most distinct with the oxygen, chlorine, iodine, and bromine compounds, as well as with the sulphate and carbonate, but is also distinctly seen in the silicate and other non-volatile salts.

By volatilizing a known weight of soda in a room, the dimensions of which were known, and observing the effect produced upon a non-luminous flame, Bunsen and Kirchhoff have shown that the optical reaction is sufficiently delicate to detect less than the $\frac{1}{2,000,000}$ of a milligramme of soda. It will easily be conceived from this that the atmosphere almost always gives a more or less distinct sodium reaction. The authors suggest that daily and long continued spectral observations may possibly show a connection between the presence and distribution of endemic diseases, and the quantity of sodium in the atmosphere, since chlorid of sodium is an antiseptic substance.

From the inconceivable delicacy of the sodium reaction, it will readily be understood that substances which have been in contact with the atmosphere even for a short time, rarely fail to produce the characteristic spectral line. Striking a dusty book for example produces at a distance of several steps the strongest sodium reaction.

Lithium.—The ignited vapor of lithium compounds exhibits two sharply defined lines, a very faint yellow line Li α, and a brilliant red line Li β. The former lies between Fraunhöfer's lines, C and D, but nearest to D—the latter lies between B and C. The reaction is somewhat less sensitive than that for sodium, perhaps because the eye is more sensitive to yellow than to red rays. The authors find that less than $\frac{1}{1,000,000}$ of a milligramme of carbonate of lithia can be detected with the greatest certainty.

Minerals containing lithia like triphyllin, triphane, petalite, etc., require only to be held in the flame in order to give the most intense line Li α. In this manner the presence of lithia in many feldspars may be immediately detected. Direct observation fails however to detect lithia when present in very minute quantities in natural silicates. In such cases the following process may be adopted: a small portion of the substance is to be digested and evaporated with fluo-hydric acid or fluorid of ammonium, the residue is to be evaporated with a little sulphuric acid and the dry mass extracted with absolute alcohol. The alcoholic solution is to be evaporated to dryness and again extracted with alcohol, and the solution evaporated on a flat watch glass. The residue is to be scraped up with a knife and introduced into the flame by means of the platinum wire: $\frac{1}{10}$ of a milligramme is usually quite sufficient for the experiment.

This process places beyond a doubt the unexpected fact that lithia is one of the most universally diffused substances in nature. The authors have detected it in sea-water, in the ashes of seaweeds, and of various species of wood growing on granitic soils, as well as in many minerals and in spring waters. A mixture of volatile soda and lithia salts gives the reactions of lithia with scarcely diminished distinctness. In consequence of the greater volatility of the lithia salts, the sodium reaction usually lasts rather longer than that of the lithia. In order therefore to recognize the presence of very small traces of lithia, when mixed with soda, the test should be placed in the flame while the observer is looking through the telescope: the lithium line is then often observed only for a few instants, among the vapors which first arise.

Potassium.—Potassium compounds give in the flame a very extended continuous spectrum, which exhibits only two characteristic lines—one at the extreme outer border of the red rays, Ka α, exactly corresponding to the dark line A of the solar spectrum, the other Ka β far in the violet, also corresponding to a dark line in the solar spectrum between G and H, but much nearer to the latter. A very faint line corresponding to Fraunhöfer's line B is only visible when the light is very intense, and is not very characteristic. The blue line Ka β is rather faint but as well adapted as the red line to the detection of potassium. The position of the two lines near the limits of the visible rays renders the reaction less delicate; only about $\frac{1}{1,000}$ of a milligramme of potassium can be rendered visible in this manner.

All the volatile compounds of potash exhibit this reaction: silicates and other fixed salts only yield it when the quantity of potash is very large. When the quantity of potash is small, it is only necessary to fuse the substance with carbonate of soda, in order to produce the characteristic lines. To detect extremely slight traces of potash, the silicate must

be gently ignited upon a platinum crucible with a large excess of fluorid of ammonium and the residue introduced into the flame by the platinum wire. In this manner, it is found that nearly all silicates contain potash. The presence of salts of lithium and sodium do not sensibly affect the reaction; thus it is sufficient to hold the ashes of a cigar in the flame before the slit, in order to detect immediately the yellow line of sodium and the two red lines of potassium and lithium.

Strontium.—The spectra of the alkaline earths are much less simple than those of the alkalies: that of strontium is specially characterized by the absence of green lines. Eight lines are very remarkable in this spectrum—six red, one orange, and one blue. The orange line Srα which lies close to the sodium line, the two red lines Srβ and Srγ and the blue line Srδ are most important from their position and their intensity. The authors find that $\frac{6}{1\,0\,0\,0\,0\,0\,0}$ of a milligramme of chlorid of strontium may be detected by the spectral reaction. In order to detect strontium in its less volatile compounds, as in sulphates, silicates, etc., it is best to fuse the substance to be tested, with carbonate of soda, and to moisten the fused mass with muriatic acid. The authors give a very simple and elegant process for effecting the fusion in a spiral of platinum wire, for which however, we must refer to the original memoir. The reactions of potassium and sodium are not disturbed by the presence of strontium. The lithium reaction is also distinctly seen when the proportion of lithium to strontium is not too small.

Calcium.—The Calcium spectrum may be readily distinguished from the four spectra hitherto described by the presence of a highly characteristic and intense line in the green, Caβ. The very intense orange line, Caα, which lies considerably farther toward the red end of the spectrum, than the sodium line, Naα, or the strontium line, Srα, is not less characteristic.

Kirchhoff and Bunsen find that $\frac{6}{1\,0\,0\,0\,0\,0}$ of a milligramme of chlorid of calcium may be easily and certainly recognized by the spectral analysis. The volatile compounds of calcium exhibit the reaction with the greatest distinctness: sulphate and carbonate of lime give the spectrum, as soon as the salt begins to become basic.

The compounds of calcium with fixed acids are indifferent in the flame. Those which are attacked by muriatic acid may be advantageously treated as follows: A small quantity of the finely pulverized substance is introduced on the platinum wire into the less hot portion of the flame, until the powder packs together without fusing. A drop of muriatic acid is then added, so that the greater part of it remains in the loop of the wire. On bringing this drop into the hottest part of the flame, it evaporates without boiling, and at the instant that the last portions are evaporated, a brilliant calcium spectrum is seen.

Those silicates which are not attacked by muriatic acid, are most advantageously treated by heating the very finely pulverized substance on a flat platinum crucible cover with about a gramme of half deliquesced fluorid of ammonium, and igniting after the volatilization of the latter. The residue is then to be moistened with one or two drops of sulphuric acid, and the excess of this expelled by heat—the substance thus prepared is then to be introduced into the flame. When potassium, sodium, lithium

and strontium are all present together, the characteristic reactions of the alkalies appear first; those of calcium and strontium usually somewhat later. When these last are present only in very minute quantities, their spectral reactions do not appear; we obtain them however, immediately when the wire is moistened with muriatic acid, and held for a few moments in the reducing flame.

The authors point out the importance of these simple processes in a geological and minerological point of view. Thus sea-water is easily shown to contain potassium, lithium, calcium, and strontium, and many other very interesting and important examples are given.

Barium.—The spectrum of Barium is the most complicated of all those yet investigated. It contains two bright green lines between the spectral lines E and F but nearer to E; these the authors denote by Ba α and Ba β. A third line Ba γ is less sensitive, but still characteristic. The spectral reaction of the barium compounds is somewhat less sensitive than that of the metals already considered: about $\frac{1}{1.0000}$ of a milligramme of barium is exhibited with perfect distinctness. The chlorid, bromid, iodid, fluorid, hydrated oxyd, carbonate and sulphate of barium give the reaction immediately on heating in the flame. Those silicates which are attacked by muriatic acid, must be treated in the manner pointed out for the silicates of lime. Other silicates should be fused with carbonate of soda, as in the case of strontium. In a mixture containing chlorids of all the six metals and at most $\frac{1}{10}$ of a milligramme of each, each metal was readily detected by the spectral analysis.

In conclusion, the authors point out the great advantages of the new method of qualitative analysis in detecting the presence of minute quantities of particular substances and in tracing their distribution upon the surface of the earth. They even venture to assert that there exists a hitherto undiscovered metal belonging to the same group with potassium, sodium and lithium, which gives a spectrum as simple and characteristic as that of lithium. This spectrum exhibited with their apparatus, only two lines—one, a faint blue, which almost corresponds to the strontium line, Sr δ and the other a blue line which lies a little farther toward the violet end of the spectrum and compares in intensity and distinctness with the lithium line.

The spectral analysis promises to furnish also a method of investigating the chemical nature of the atmospheres of the sun and of the brighter fixed stars.

Kirchhoff has shown from theoretical considerations, that the spectrum of an ignited gas is inverted when a source of light of sufficient intensity and giving a continuous spectrum, is placed behind it. In other words, the bright lines are under these circumstances converted into dark ones. From this it appears, that the solar spectrum with its dark lines is nothing else than the inversion of the spectrum, which the atmosphere of the sun would show by itself. The chemical analysis of the sun's atmosphere requires us therefore only to determine what substances introduced into a flame will produce bright lines, corresponding to the dark lines in the sun's light. The authors have verified by direct experiment the above conclusions, and have inverted the bright lines of potassium, sodium, lithium, calcium, strontium and barium. They promise a further extension of

their very beautiful and valuable investigations.—*Pogg. Ann.*, cx, 161, June, 1860.

[NOTE.—The inferences of Kirchhoff and Bunsen with respect to the chemical nature of the sun's atmosphere require two assumptions neither of which is as yet supported by observation. The first is that the body of the sun is intensely luminous and that its spectrum contains no dark lines: the second is that no substances except those of which our earth is composed and with which we are acquainted exhibit in their spectra bright lines corresponding to the dark lines in the solar spectrum as we see it.—W. G.]

2. *On some numerical relations between the densities and equivalents of certain elements.*—PLAYFAIR has communicated to the Royal Society of Edinburgh some remarkable observations on the densities of several of the elements. The numerical relation which the author has detected amounts simply to this—that the densities are in certain cases accurately represented by the square roots, cube roots, or fourth roots of the equivalents. In obtaining the densities, the author takes a mean of all the best recorded observations in each case. The following table exhibits his results which are certainly very striking, the coincidences being too numerous and too perfect to be accidental:

	Equivalents.	Density as found.	Density as Calculated.
Diamond,	12	3·48	$\sqrt[3]{12} = 3{\cdot}46$
Graphite,	12	2·29	$\sqrt[3]{12} = 2{\cdot}28$
Charcoal,	12	1·38	$\sqrt[4]{12} = 1{\cdot}36$
Silicon, (adamantoid,)	14·2	2·46	$\sqrt[3]{14{\cdot}2} = 2{\cdot}42$
Silicon, (graphatoid,)	28·4	2·33	$\sqrt[4]{28{\cdot}4} = 2{\cdot}30$
Boron, (adamantoid,)	7·2	2·68	$\sqrt[3]{7{\cdot}2} = 2{\cdot}68$
Bromine,	80·0	2·98	$\sqrt[4]{80} = 2{\cdot}99$
Iodine,	127·0	4·99	$\sqrt[3]{127} = 5{\cdot}02$
Sulphur,	16	2·00	$\sqrt[4]{16} = 2{\cdot}00$
Selenium,	80	4·31	$\sqrt[3]{80} = 4{\cdot}31$

It will be seen that there are some inconsistencies in the selection of the equivalents which however only affect the degree of the root to be extracted. It remains to be determined whether the other elements exhibit similar relations.—*Chemical News*, No. 27 and 29, 1860. W. G.

3. *On the Loss of Light, by Glass Shades;* by WM. KING of Liverpool, and Prof. VERVER of Maestrecht; *with a note of additional experiments;* by FRANK H. STORER.* Under date of Feb. 24, 1860, Mr. King writes to the Editor of the London Journal of Gas Lighting, etc., (see vol. ix, p. 111,) as follows: "Sir,—Having recently tried some experiments for the purpose of ascertaining the amount of light lost by the use of various descriptions of glass shades, I thought that the results obtained might prove not uninteresting to some of your readers, more especially as it is a subject of practical importance, and does not seem to have attracted the notice which it deserves.

The following table exhibits the amount of light lost by the use of the various shades therein enumerated:—

* Communicated for this Journal, by Mr. Storer.

Description of shade.	Loss of light.
Clear glass, - - - - - -	10·57 per cent.
Ground glass, (entire surface ground	29·48 "
Smooth opal, - - - - -	52·83 "
Ground opal, - - - - - - - -	55.85 "
Ground opal, ornamented with painted figures, the figures intervening between the burner and the photometer screen, -	73·98 "

As the large amount of light lost by the use of a clear glass shade excited some surprise, a sheet of common window glass was placed between the burner and the photometer screen, when it was found that 9·34 per cent of the light was intercepted, thus confirming the result obtained by the employment of a shade of clear glass.

I may state that the shades were selected from a large number, and great pains were taken to obtain an average specimen of each kind."

It should be mentioned in passing that Verver* had previously called attention to the subject in these words :—" It is not necessary to surround the wicks [of platinum, placed in the flame of the ' water gas,'] with glass chimneys as is done with ordinary coal gas ; on the contrary it is preferable not to employ them, because the chimneys, no matter how well polished or how clean they may be, always absorb a considerable portion of the light which is produced. This loss (*déperdition*) was shown by the following experiment. A burner with twelve jets without any chimney afforded an illuminating power of 6·75 candles ; but on surrounding the wick with a clean and perfectly polished chimney, the illuminating power amounted only to 5·25 candles ; it had consequently diminished 1·50 candles, *i. e.*, 22 per cent." But, as Schilling† has already remarked, this experiment alone does not prove that the whole of the lost 22 per cent was absorbed by the glass of the chimney, since the conditions under which the gas is consumed when a chimney is used must be entirely different from those which obtain when no chimney is employed.

Immediately after the arrival in this country of the journal containing Mr. King's note, I was requested by Mr. W. W. Greenough, Agent of the Boston Gas Light Co., to institute a series of comparative experiments upon this subject. Since the results of these experiments have in the main fully corroborated those of Mr. King it seems but just to this gentleman to give them publicity.

Instead of lamp shades, flat sheets of glass (ordinary window panes) six inches wide by eight inches high, were fitted to a rack of blackened wire which was fastened to the photometer bar (100 inches long) at a distance of three feet from the gas light.‡

The gas employed was prepared, from the caking coal of Pictou, N. S., expressly for these experiments and was contained in a special gas-holder.

* *L'Éclairage au Gaz à L'Eau à Narbonne et L'Éclairage au Gaz Le Prince, examinés et comparés par le* Dr. B. Verver, *Prof. de Chimie et de Physique à l'Athénée Royale de Mæstricht.* Leide, 1858, p. 26.

† In his *Journal für Gasbeleuchtung, etc.* München, 1859, ii, 377.

‡ It does not appear that the distance from the source of light at which the glass screen is placed has any appreciable influence upon the amount of light transmitted by it. At all events no such influence could be detected in a number of experiments made purposely to test this question.

The "illuminating power" of this gas when consumed from the Parliamentary Argand burner* at the rate of five cubic feet per hour—as in the following experiments—was equal to 16·00 candles consuming 120 grains, by calculation, (in reality about 135 grains as carefully determined by the balance in each case) of spermaceti per hour.

The experiments were made in the blackened experimental chamber of the Boston Gas Light Co., with the photometer (Bunsen's) which I am accustomed to employ in my daily tests of the gas furnished by the Company to consumers, every precaution being taken to ensure accuracy. It may also be mentioned that none of the measurements (of the distances of the photometer, from the standard candle) obtained by actual experiment were calculated,—*i. e.*, reduced to their equivalents in candles,—until the whole series of experiments was completed, and that no comparison of my own results among themselves or with those of Mr. King was made until each member of the table had been calculated as it stands below. Whatever the experiments may be worth therefore, they have at least the merit of being entirely independent and wholly unbiassed.

Description of glass.	Thickness of glass.	Loss of light.
Thick English plate,	$\frac{1}{3}$ of an inch,	6·15 per cent.
Crystal plate,	$\frac{1}{8}$ "	8·61 "
English crown,	$\frac{1}{8}$ "	13·08 "
"Double English," window glass,	$\frac{1}{8}$ "	9·39 "
"Double German,"† "	$\frac{1}{8}$ "	13·00 "
"Single German,"† "	$\frac{1}{16}$ "	4·27 "
Double German,† ground,‡	$\frac{1}{8}$ "	62·34 "
Single German,† ground,‡	$\frac{1}{16}$ "	65·75 "
Berkshire, (Mass.,) ground,‡	$\frac{1}{16}$ "	62·74 "
Berkshire enameled, *i.e.*, ground only upon portions of its surface,—small figure,	$\frac{1}{16}$ "	51·23 "
"Orange-colored" window glass,	$\frac{1}{16}$	34·48 "
"Purple" " "	$\frac{1}{8}$	85·11 "
"Ruby" " "	$\frac{1}{16}$	89·62 "
"Green" " "	$\frac{1}{16}$	81·97 "
	As used for church windows, &c.	
A porcelain transparency, (Tyrolese Hunter,)	$\frac{1}{16}$ "	97·68 "

The term "loss of light" employed by Mr. King does not at first sight seem to be strictly appropriate, for a very considerable portion of the light not transmitted by a glass shade might be reflected against the walls of

* With the ordinary chimney.—Mr. King does not specify what burner was used in his experiments, but it was probably the "fish-tail," which has been so often recommended as a standard by his father, consuming four feet per hour, of course without a chimney.

† Among the Boston dealers, the term German is applied to glass of Belgian manufacture.

‡ The enormous resistance to the passage of light which is offered by ground glass is certainly worthy the attention of those using it for windows, &c.

The discrepancy between Mr. King's results and my own as regards ground glass may perhaps be owing to the fact, that the window glass used by myself was *more coarsely ground* than the lamp shades employed by him.

the apartment in which the lamp is burning and thus aid in the general illumination of the room. The meaning which Mr. King attaches to the term is however so perfectly evident that I have not hesitated to follow him in using it. For that matter, there can be no doubt but that the numbers given by us express as accurately as the circumstances of the case will admit, the actual diminution of the amount of light, falling for example upon the pages of a book held near to its source, which would be occasioned by the interposition of the shades enumerated in our tables.

Boston, April 20, 1860.

[We cannot doubt that the great loss of light proved by the experiments above given, is to be, in part at least, accounted for by the conversion of a portion of the light into heat—an effect perfectly in harmony with the theory of transverse vibrations as applied to explain the phenomena of polarization of heat. On this theory, heat and light are different effects produced by one and the same cause, and they differ physically only in the rapidity and amplitude of their vibrations. The screen through which the vibrations of light are propagated serves to diminish first the rapidity of the vibrations requisite to produce the most refrangible rays, and in proportion as the transparency of the screen is diminished by any cause, inherent or superficial, this arrest becomes more and more complete. As the more rapid etherial vibrations have probably the least amplitude, we infer from analogy in sound-waves, that as waves of least intensity have the greatest amplitude, so with the luminiferous ether the extreme red has but little brilliancy. Hence the loss of light from polished screens is small compared with that observed in screens of opaline or roughened glass. It would be instructive to examine the spectrum obtained from a pencil of rays under each of the cases given, by means of a sulphid of carbon prism.

The subject of absorption of light by screens has long since been carefully examined by *Bouguer*.* By a photometric method essentially like Rumford's, Bouguer measured the loss of light in the beam of a candle compared with a flambeaux and also with the light of full moon, in passing through 16 thicknesses of common window glass having an united thickness of 21·43 millimetres = ·85 inch. The mean loss of light shown by these trials was as 247 : 1, or over 99 per cent of the whole quantity.

Six plates of the purest mirror plate-glass having an united thickness of 15·128 millimetres diminished the light in the ratio of 10 to 3, occasioned a loss of about 70 per cent of diffuse daylight. A mass of very pure glass about three inches thick diminished the light only about half the latter amount, owing to its being a single mass and not cut up into many planes.

He also measured the absorbing power of sea-water for light and found as the results of experiments made in France and of observations also in the torrid zone, that at the depth of 311 French feet the light of the sun would be equal only to that of the full moon, and at the depth of 679 feet would wholly disappear. He estimates the transparency of the air as 4575 times greater than that of sea-water, and

* *Traité d'Optique sur la Gradation de la Lumiere (ouvrage posthume) : publié* par M. l'Abbé De La Caille. *Paris*, 1760, 4to, pp. 368.

from the properties of a logarithmic curve (which he calls *gradulucique*) whose functions he had determined experimentally, he seeks to fix the outer limits of the atmosphere. Bouguer was an expert geometer and sustains all his conclusions by mathematical demonstrations. His results seem to have received less attention than they merit, the only reference to his researches I have seen being by Daguin in his excellent *Traité de Physique*, iii, 300, 1859.

We should not omit in this connection to refer to the very interesting observations of Draper* on the spectrum formed by means of a platinum wire heated gradually from dull redness to perfect whiteness by a volta-electric current. He observed the red part of the spectrum to appear first and as the heat and brilliancy of the wire increased the other colors of the spectrum appeared after the violet. This result perfectly harmonizes with views above expressed.—B. S., JR.]

ASTRONOMY.—*New Planets.*—A new planet, the 59th of the group between Mars and Jupiter, was discovered Sept. 15, 1860, by Mr. James Ferguson, of the Washington (D. C.) Observatory. It was then about as bright as a star of the 11th magnitude.—*Gould's Astron. Journal*, No. 140.

The 58th Asteroid (since named *Concordia*) was discovered March 24, 1860, by Dr. Luther of the Observatory at Bilk.

PERSONAL.—Prof. J. D. WHITNEY, State Geologist of California, sailed from New York for his post of duty on the 22d of October last with Prof. WM. H. BREWER (late of Washington College, Pa.) in charge of the Department of Agricultural Chemistry and Botany, and Mr. WILLIAM ASHBURNER who is assistant in the field Geological and Astronomical work. The head-quarters of the survey will be for the present at San Francisco. But the Act authorizing the survey contemplates the establishment of a State museum, on the most extensive scale, the location of which is to be determined by a future legislature, which place, wherever it may be, will doubtless be also the permanent head quarters of the survey. For the present, letters addressed to any member of the corps, "State Geol. Survey, San Francisco," will reach their destination. Parcels or books for Prof. Whitney or any member of the corps may be sent to care of B. Westermann & Co., 440 Broadway, New York. No similar enterprise in the United States has ever been set on foot on a more liberal and enlightened basis, or opened under more favorable auspices as respects either the importance of the work to be done or the ability of those charged with the duty.

THE GENERAL INDEX to the 3d decade of volumes of the 2d Series of this Journal, now complete, occupies more than the space usually appropriated to our Scientific Intelligence, and our numerous friends, whose contributions are thereby excluded from the present issue, will pardon the unavoidable delay.

OBITUARY.—Died in Montreal, Oct. 9, Dr. W. P. HOLMES, well known as an early cultivator of mineralogy and botany in Canada, an active promoter of the Montreal Natural History Society, and for the last ten years professor of Medical Jurisprudence in McGill College, Montreal.

* This Journal [2], iv, 388, and v, 1.